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BY B. P. WEBB

Summary

THE GEOLOGICAL STRUCTURE OF THE BLINMAN DOME

by B. P. WEBB*

[Read 10 November 1960]

INTRODUCTION

In November, 1958, whilst engaged on mapping the Willochra one-mile sheet for the Department of Mines, the author and C. Von der Borch made a brief field inspection of the structure known as the Blinman Dome. Observations made on this inspection suggested that the Blinman Dome was a diapiric structure, related to diapiric phenomena mapped on the Willochra Sheet (Geol. Surv. S. Aust.).

In July, 1959, the Department of Mines undertook a gravity traverse across the structure, extending out into the neighbouring country for several miles. Subsequently, additional traverses were run to confirm the preliminary results, and at the same time an opportunity was taken to geologically map portion of the central part of the structure, and determine its relationships to the enclosing country rocks. The geophysical surveys were carried out by I. A. Mumme, and the author spent several days in the field on the geological investigation. Petrological examinations of various rock samples were carried out by W. Fander of the Australian Mineral Development Laboratories.

PREVIOUS WORK

Petrological notes on certain of the igneous rocks of the region were made by Benson (1909), and geology of the area briefly discussed by Howchin (1922). Mawson (1939, 1942, 1949) carried out stratigraphical studies in this region, and Dickinson (1942) described the geology of the Blinman Mine.

Howard (1951) carried out a detailed geological investigation of the Blinman Dome and surrounding area, with particular reference to the basic igneous rocks, and this work has been of great value to the author. The present paper is largely a reassessment of the data recorded by Howard.

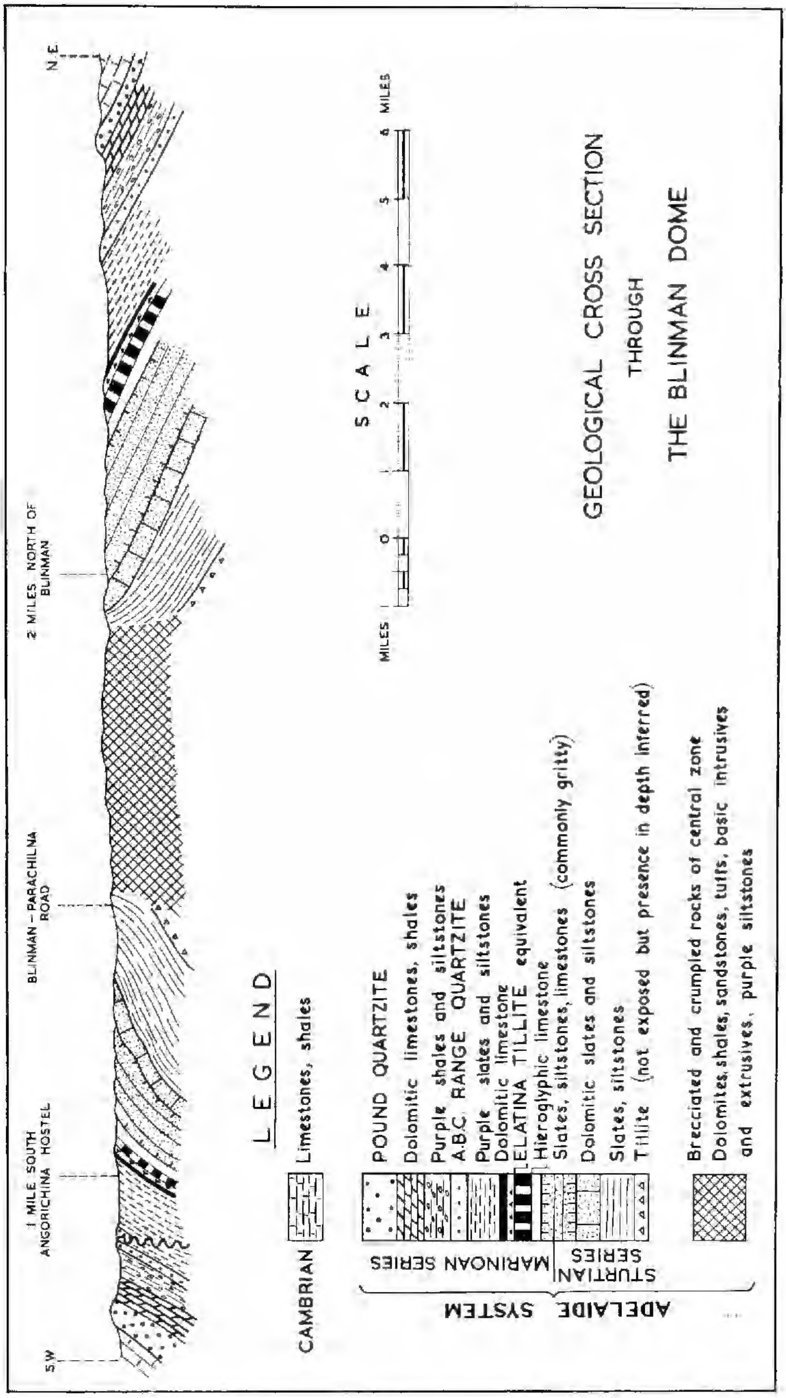
The author (1960) reported briefly on the results of mapping carried out at Blinman.

REGIONAL GEOLOGY

As shown on Howard's map, the Blinman Dome consists of a central core of disturbed and brecciated rock, occupying an area of some 18 square miles, surrounded by Adelaide System and Cambrian sediments dipping outwards from the central structure.

The succession in the Adelaide System and Cambrian sediments surrounding the dome is illustrated in the accompanying cross-section (Fig. 1), and can be summarised as under. Thicknesses have been estimated from field observations supplemented by photogeological studies, and refer to the section exposed on the eastern side of the Dome.

* Geological Survey of South Australia.


S.W.
1 MILE SOUTH ANGORICHINA HOSTEL
BLINMAN - PARACHILNA ROAD
2 MILES NORTH OF BLINMAN
N.E.
LEGEND
CAMBRIAN
Limestones, shales
ADELAIDE SYSTEM
MARINOAN SERIES
POUND QUARTZITE
Dolomitic limestones, shales
Purple shales and siltstones
A.B.C. RANGE QUARTZITE
Purple slates and siltstones
Dolomitic limestone
ELATINA TILLITE equivalent
Hieroglyphic limestone
STURTIAN SERIES
Slates, siltstones, limestones (commonly gritty)
Dolomitic slates and siltstones
Slates, siltstones
Tillite (not exposed but presence in depth inferred)
Brecciated and crumpled rocks of central zone
Dolomites, shales, sandstones, tuffs, basic intrusives and extrusives, purple siltstones
SCALE
MILES 1 0 1 2 3 4 5 6 MILES
GEOLOGICAL CROSS SECTION
THROUGH
THE BLINMAN DOME

Cambrian

(1)	7000 ft. (plus)	Fossiliferous limestones, shales, sandstones.

Adelaide System

(2)	1300 ft.	Pound quartzite.
(3)	2000 ft.	Dolomitic limestones, shales.
(4)	1800 ft.	Purple shales and siltstones.
(5)	800 ft.	A.B.C. Range Quartzite.
(6)	5100 ft.	Purple slates and siltstones.
(7)	20 ft.	Dolomitic limestone.
(8)	600 ft.	Purple sandstone, with tillitic lenses (Elatina Tillite equivalent).
(9)	2100 ft.	Hieroglyphic limestone.
(10)	4000 ft.	Slates, siltstones, limestones (commonly gritty).
(11)	1500 ft.	Dolomitic siltstones and slates.
(12)	4000 ft. (plus)	Siltstones and slates, with local pockets of tillitic material in lowest exposed beds.

This succession is essentially the same as that described by Howard, with some additions and modifications. Of interest is the recognition of the Elatina Tillite equivalent horizon, and an overlying thin but persistent buff-coloured flaggy dolomitic limestone (items 8 and 7 above).

These units were not specified by Howard, but would be included in subdivision 13 on his map — "chocolate and grey shales". They correspond directly to items 45-46 and 47 respectively of Mawson's (1939) Brachina Gorge Section, the former being subsequently (1949) named by him the Elatina Tillite. This horizon was recognised on the eastern and western sides of the dome, and is well exposed in a creek bed half mile south-west of Angorichina Hostel.

Items 8, 9 and 10 (above) together comprise the "upper glacial sequence" (Webb and Horwitz, 1959). The Sturtian-Marinoan Series boundary has been placed in the upper portion of the 4000 ft. section of slates, siltstones and gritty limestones (item 10).

Howard suggested that the lowest beds exposed around the rim corresponded to the "greywacke grit" horizon of Mawson (1942). However, the present mapping shows that on the south-western side of the structure even lower beds are exposed before the true outer edge of the structure is reached. They consist of massive siltstones and slates, with local tillitic lenses, and are concluded to represent the uppermost portion of the "lower glacial sequence" (Webb and Horwitz, 1959). In this area the author places the boundary of the disturbed central zone up to three-quarters of a mile further in towards the centre of the structure than shown on Howard's map.

The Cambrian and Adelaide System rocks are draped around the central area in the form of a large regional dome, dips being generally less than 45 deg. In the immediate vicinity of the disturbed central area, the surrounding rocks are sharply upturned.

Howard recognised this unusual feature of the structure and concluded ". . . . there must have been a great force from *beneath* to lift the sediments into their upturned position. . . ." (italics the present author's). This sudden upturning was noted wherever the contact was examined during the present study, and is apparent along the south-western margin where upturning was not recognised by Howard. Here dips steepen from 30 deg. to vertical over a distance of 500 yards.

Of interest is the noticeable thinning of certain of the surrounding beds as they approach the structure from the south-east side. Measured sections

through the hieroglyphic limestone formation in this area show a decrease in thickness from 2100 feet to 1300 feet in less than three miles. Over the same interval the overlying purple sandstones and grits (Elatina Tillite equivalent) decrease from 600 feet to 400 feet. These relationships suggest an original sedimentary thinning, which could perhaps be related to early uplift in the domal area, but further mapping is needed before any conclusions can be reached.

GEOLOGY OF THE CENTRAL AREA

The brecciated and deformed rocks within the central area are made up of a variety of sedimentary and igneous types. Ripple marked and crossbedded sandstones and quartzites are common, and locally contain interbedded basic lava flows. The finer grained sandstones frequently contain halite pseudomorphs. Purple shales and siltstones (some tuffaceous) and dolomitic rocks occur locally, and there are numerous small scattered "plugs" of basic rock. The rocks are frequently intensely deformed, with resulting confused structure, and much of the central country is a breccia, made up of the above components. Sideritic veins locally traverse the breccia near the margins of the structure, and sometimes extend out into the siltstones and slates of the surrounding rim rock.

Howard concluded that the rock types in the central country corresponded to the slate, arenaceous slate and flaggy quartzite overlying the Sturt Tillite. However, these rock types are quite unlike those which could be expected to occur in the central area if the normal succession continued below the rim rocks. In the region to the south, near Oraparinna, where this part of the section is exposed, units broadly equivalent to the rim rocks are succeeded in depth by fluvio-glacial beds leading downwards to true (Sturt) tillite.

Ripple marked sandstones with halite pseudomorphs, and interbedded basic lava flows, are quite out of character with the normal Sturtian succession for this region. Mawson (1942) had previously suggested that the deformed rocks in the vicinity of Blinman were equivalent to rocks in the Oraparinna region, occurring unconformably *below* the Sturt Tillite, and it is considered that this conclusion is probably more correct. However, as Howard points out, there is no evidence of unconformity at the contact in the Blinman area.

It is apparent that most of the rocks in the centre country belong stratigraphically below the Sturtian and that they have been structurally emplaced in their present position. The presence of ripple marked sandstones, purple shales and interbedded lava flows are all suggestive of rock belonging to the Willouran Series as developed in the region to the north near Mt. Painter. A specimen of basic lava collected from one and a half miles south of Blinman is described by W. Fander as being (on examination in thin section) "very similar to the trachytes of the Wooltana district". Rock types typical of the Torrensian (such as sedimentary magnesites) appear to be absent. Many of the rock types at Blinman recall those occurring in diapiric-type structures on the Willochra one-mile sheet, and here, too, they would appear to be more typical of the Willouran than the Torrensian. It is suggested that in the light of available evidence the rocks in the Blinman structure are mostly derived from the underlying Willouran Series.

There are numerous scattered occurrences of plug-like masses of doleritic rock, which Howard grouped into a "younger" doleritic suite, concluding that the intrusion of these rocks was responsible for the formation of the Blinman structure. (In the field it is difficult to distinguish these rocks from certain of the basic lavas.) It is apparent from Howard's map that these basic igneous intrusives make up a relatively small proportion of the total outcrop area of the

central core. The presence of a small but distinct gravity low over the central area (established by the associated geophysical work carried out) indicates that it is unlikely that it is underlain by a large body of basic igneous rocks, as suggested by Howard.

Many of the outcrops of fine-grained sandstones and siltstones show development of halite pseudomorphs, often associated with ripple marks and small scale cross-bedding, the latter sometimes picked out with fine heavy mineral bands. As pointed out by Howard, these are features suggestive of shallow water and arid conditions at the time of sedimentation. At one locality, some two miles west of Blinman, there is an outcrop of fine-grained arkose and siltstone containing numerous small cavities, the general shape of which are suggestive of the former presence of gypsum. A buff-coloured siltstone from an area four miles west of Blinman, containing pseudomorphs resembling halite, was submitted for chemical analysis of the soluble salt content, with following results:—

Calcium sulphate	0·04 p.c.
Magnesium sulphate	1·03 p.c.
Magnesium chloride	0·35 p.c.
Sodium chloride	2·07 p.c.

These unusually high percentages may be significant, but considerably more sampling and testing is required before any conclusions can be reached. However, it is apparent that many of the rocks exposed in the central area were deposited in shallow water and under arid conditions – conditions favourable for development of evaporites.

In addition to the rock types described above there are isolated occurrences of other types, which are of considerable interest.

Some one and a half miles north-west of Blinman is a large mass, over 50 yards across, of typical Sturt Tillite – grey green matrix with erratics. It is completely surrounded by brecciated siltstones, purple shales, etc.

Large fragments of gneissic granitic rocks up to several tons in weight occur three-quarters and two and a quarter miles north-west of Blinman, adjacent to the Moolooloo road. These granitic rocks occur as discrete fragments, surrounded by crushed and broken siltstones and sandstones showing no sign of metamorphism. It is suggested that these fragments which in the field resemble certain of the granitic rocks of the Mt. Painter region, were derived from the underlying crystalline basement. Samples of these rocks were examined in thin section, and described by Mr. Fander as "orthogneisses". Referring to a sample from the location two and a quarter miles north-west of Blinman, he states:—

"Strong crushing and shearing of an originally porphyritic granodiorite has produced gneissose and flaser structure. Relict phenocrysts of microcline are set in a ground-mass of fresh and altered oligoclase, and quartz as highly stressed, sutured aggregates. Clusters of biotite have associated xenotime, zircon, opaques, sphene and apatite. There is widespread development of very coarse-grained secondary muscovite and of calcite. Except for a higher proportion of oligoclase, which places this rock with the granodiorites, its similarity to the Flinders Ranges 'older' granite is very marked."

The suggestion by Howard that these rocks represent highly stressed extreme differentiates of the basic doleritic magma is not supported by the field and petrological evidence.

In a few localities large fragments of grey siltstone, typical of the Sturtian rocks at the rim, were observed within the structure.

Most of the rocks within the structure have been intensely deformed, and frequently strongly brecciated. In some areas, particularly in the south-eastern part of the structure, there are very large blocks of folded sediments up to half a mile long, surrounded (in plan) by completely brecciated material. The general structural pattern appears to be quite confused.

The presence of large blocks of crystalline basement material and of sediments belonging stratigraphically well below the rim rocks, together with the confused and brecciated structure, are features suggestive to the author of a diapiric type structure. The blocks of basement appear to have been caught up with the diapiric sediments and "intruded" with them.

Copper mineralisation is occasionally developed, usually in dolomitic-quartzo-felspathic rocks. The Blinman Mine occurs in a dolomitic rock, associated with shales and sandstones, together forming a large mass, which appears to be surrounded (in plan) by completely brecciated material.

CONCLUSIONS

The material forming the crumpled and brecciated core of the Blinman Dome consists for the most part of strata belonging stratigraphically to rocks below the Sturtian Series, forcibly intruded into their present position, and resulting in marked local upturning of the surrounding Sturtian rocks. The presence of rocks formed under arid shallow water conditions suggests that relatively low density evaporite type sediments assisted the development of a large-scale diapiric structure before and during the folding of surrounding Adelaide System and Cambrian rocks. The concept of a large mass of basic intrusive rock underlying and causing the structures, is not in agreement with observed geological and geophysical data.

ACKNOWLEDGMENTS

The author is grateful to Mr. T. A. Barnes, Director of Mines, for permission to publish this paper, and to Mr. L. W. Parkin, Deputy Director of Mines, for interest and help in this work. The work of the Drafting Section of the Geological Survey in preparation of the accompanying illustrations is gratefully acknowledged. The assistance of Mr. W. Fander of the Australian Mineral Development Laboratories is much appreciated.

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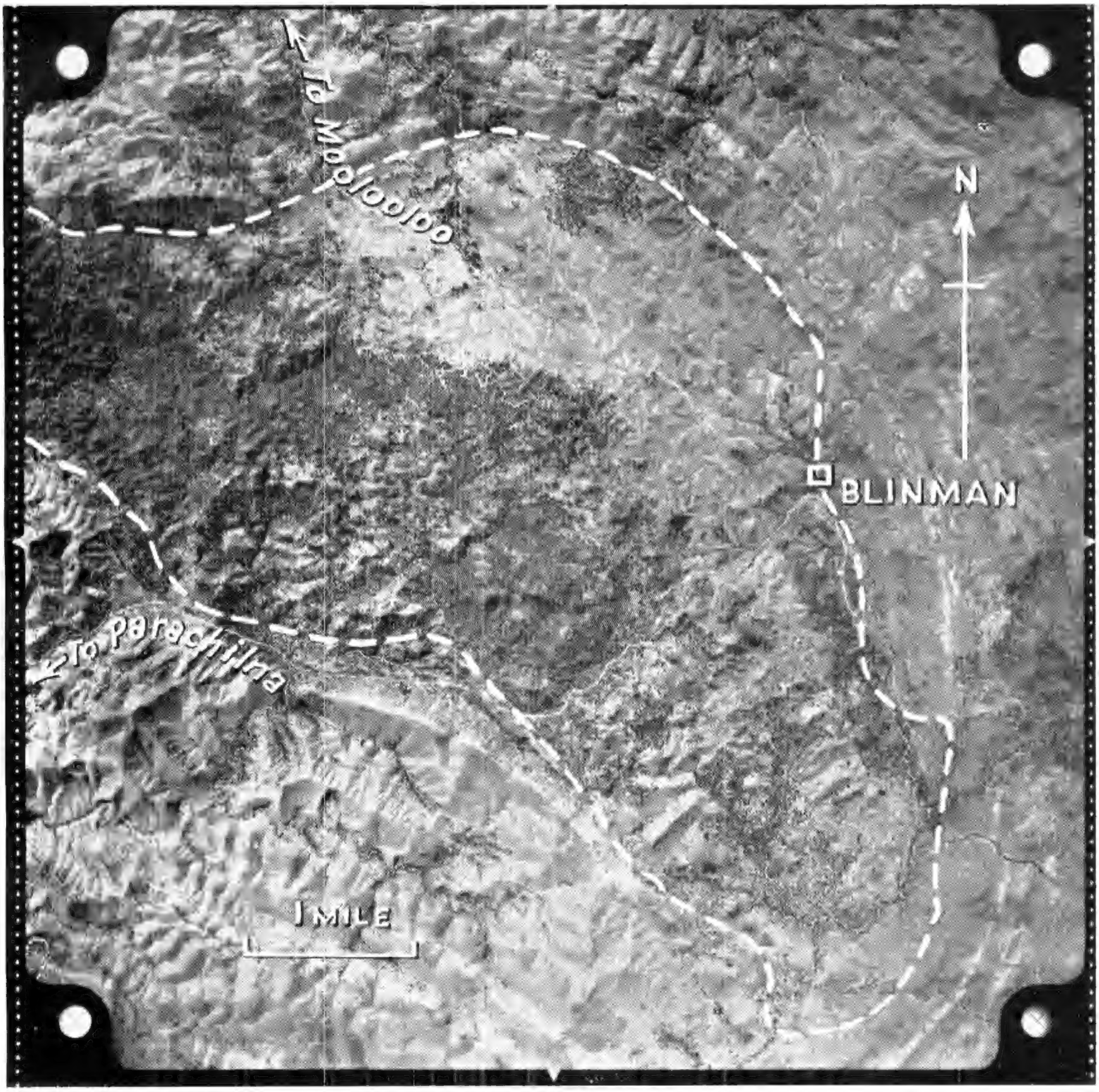

Aerial photo of portion of the Blinman Dome structure, showing the disturbed central area, surrounded by outward dipping strata of the flanking rim rocks. The limits of the disturbed central area are indicated.

Fig. 1. View along the south-western rim of the Blinman Dome structure, looking north-west. Rocks of the disturbed central area occupy the foreground and right-hand portion of the photo.

Fig. 2. Outcrop of a large element of granitic rock occurring in the brecciated central zone two and a quarter miles north-west of Blinman. The line of hills in the background is formed of steeply upturned strata along the northern rim of the structure. View looking north-west.

Fig. 1. Crumpled rocks of the central zone, adjacent to the Blinman-Parachilna road.

Fig. 2. Brecciated material of the central zone, near the south-western rim of the structure, adjacent to the Blinman-Parachilna road.

GEOPHYSICAL INVESTIGATION OF THE BLINMAN DOME

BY I. A. MUMME

Summary

The results of a geophysical investigation carried out on the Blinman Dome show a small gravity "low7' over the structure suggesting that the rock formations beneath the central portion of the dome are generally less dense than those comprising the surrounding area. Surface density measurements are in general in agreement with the gravity results. No significant magnetic variations were observed. It is concluded that the results are broadly in agreement with the structure being of diapiric origin, as suggested by geological mapping.

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[Read 10 November 1960]

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It is concluded that the results are broadly in agreement with the structure being of diapiric origin, as suggested by geological mapping.

INTRODUCTION

Although the dome structure at Blinman had been recognized many years ago by geologists, the first theory suggested as a possible mechanism of its cause was published by Howard (1951).

He considered that it was caused by the intrusion of a plug of basalt deep in the structure and that the exposures of basic rocks are genetically related to a deep-seated parent basalt plug.

During 1958, C. von der Borch and B. P. Webb, after a brief inspection suggested that the structure was essentially diapiric by analogy with similar smaller structures on the Willochra sheet fifty miles to the south. It was further suggested that a short programme of detailed mapping in the Blinman area be combined with a geophysical investigation with particular reference to gravity variations, to provide further data on the question of the origin of the structure.

The geophysical investigation consisted of several gravity and magnetic traverses across the dome and its surroundings. Density measurements were carried out on rock formations located in the area investigated to aid in the interpretation of the gravity results obtained.

The survey was carried out during the following periods—15th July to the 5th August, 8th September to the 9th October and from 9th November to the 19th November, 1959.

Webb (1960) described briefly the results of the associated detailed mapping study, concluding that the structure was diapiric in nature.

Gravimetric measurements have previously been conducted in the area by D. Pegum on behalf of Geosurveys of Australia.

The domal structure is developed in Upper Proterozoic rocks of the Adelaide System with a brecciated and deformed central core, approximately eighteen square miles in area.

METHODS USED

Initially two traverses were completed with a Worden gravimeter. Those are the Parachilna-Blinman-Wirrealpa traverse and the Mooloolo-Blinman-Gum Creek traverse and are designated as Traverses (1) and (2) respectively (Fig. 1).

* Geological Survey, Department of Mines, South Australia.

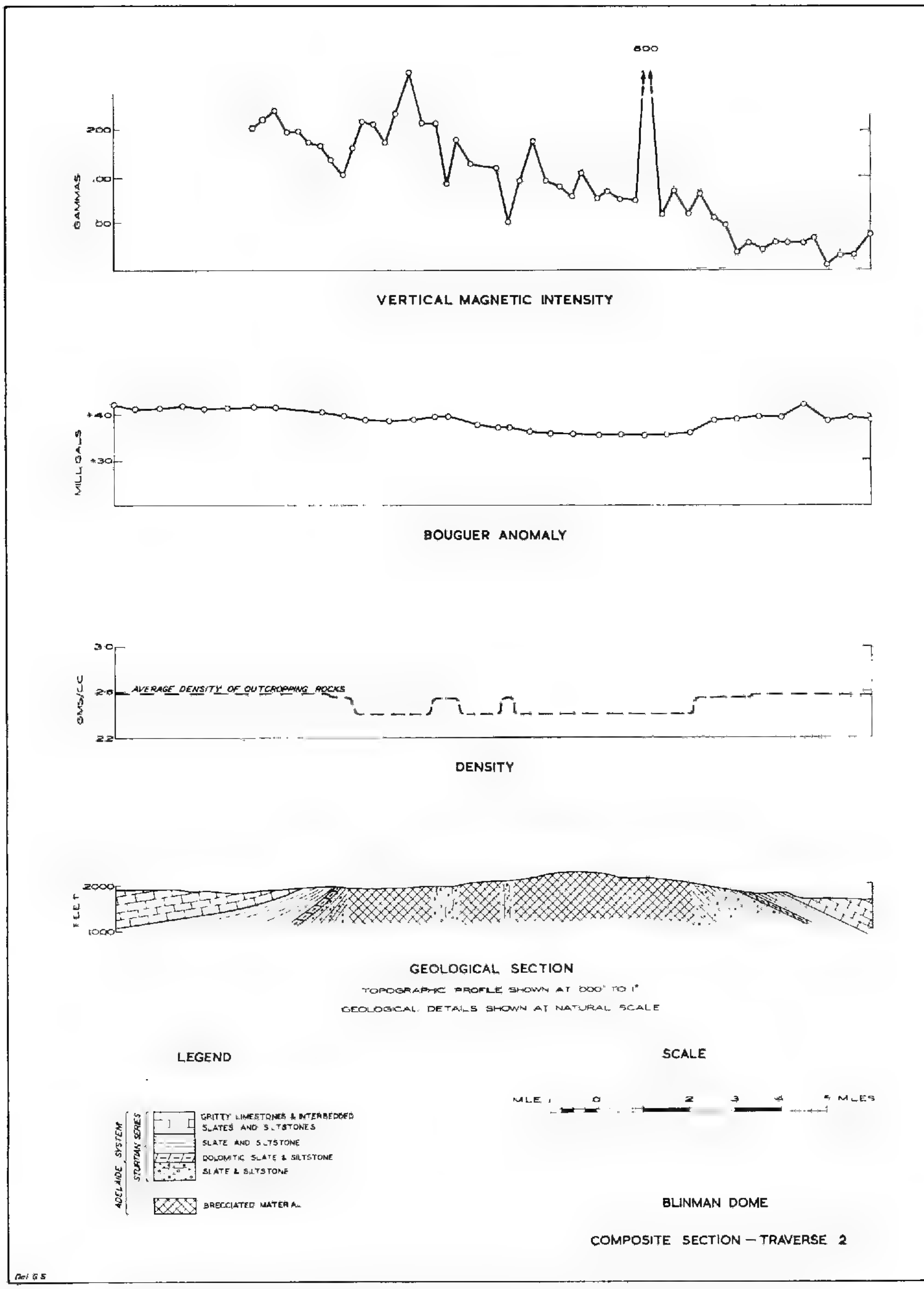

Fig. 2. Composite Geological and Geophysical Profiles for Traverse 2.

Microbarometer measurements with Askania Microbarometers for height determinations were also made at the gravity stations so that the gravity results could be reduced and plotted as Bouguer Anomalies.

Later two further traverses (Nos. (3) and (4)) were completed and reduced and a Bouguer Anomaly Plan prepared from the results of the four traverses (Fig. 1).

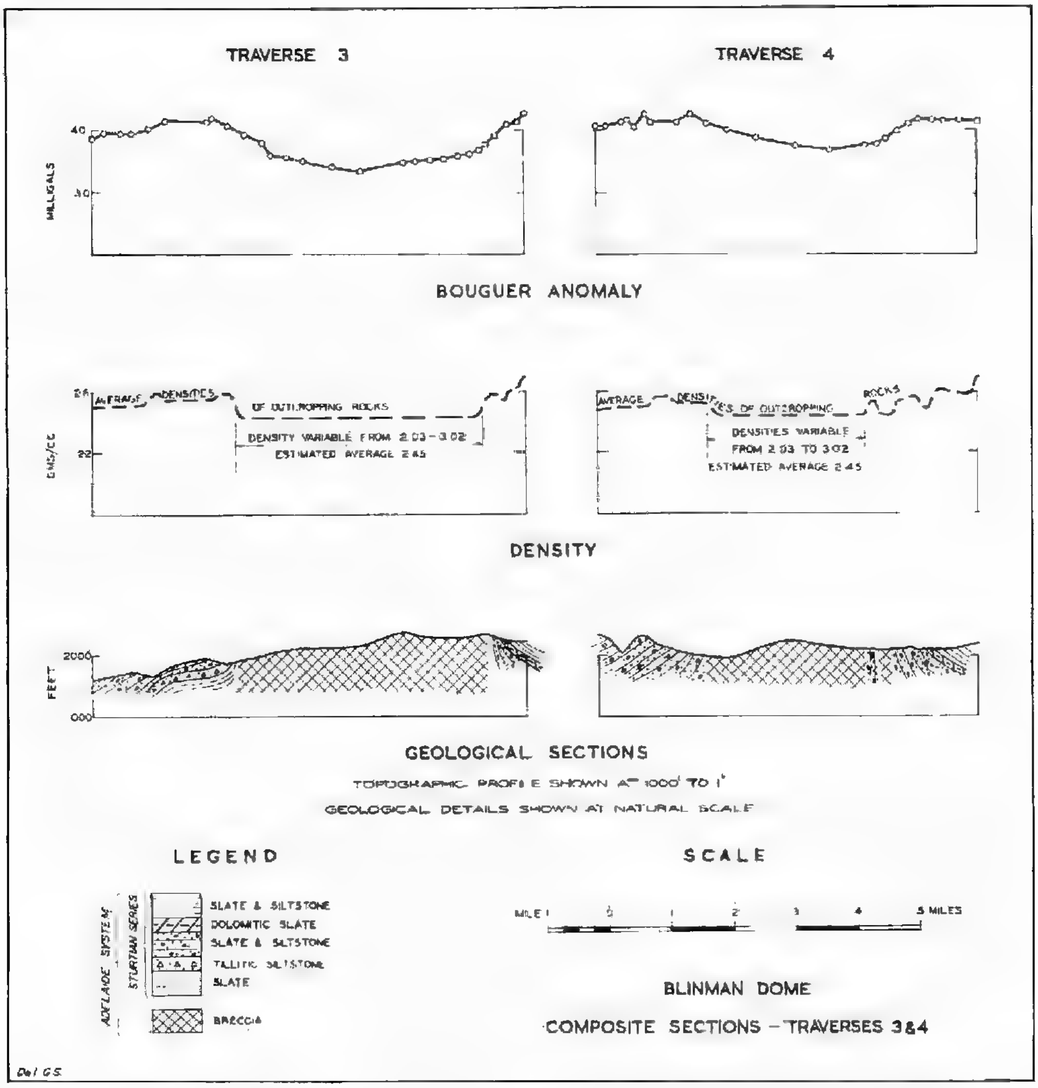

Fig. 3. Composite Geological and Geophysical Profiles for Traverses 3 and 4.

A number of rock samples were collected from along the initial two traverses (referred to as traverses (1) and (2)) and further samples were collected by B. P. Webb from traverses (3) and (4) as well as from other areas of the Dome and its surroundings including samples of basic igneous rock. Density measurements were made with a Walker's Arm Density Instrument.

A magnetic investigation of the Dome was also carried out along traverses (1) and (2) with a Hilger and Watt's vertical force magnetometer.

The gravity results were corrected, reduced and presented both as longitudinal profiles for the four individual traverses as well as a composite contour plan. Composite geological and geophysical profiles were prepared in association with B. P. Webb. The composite Bouguer anomaly contour plan (showing the position of traverse lines and location of the gravity stations) is shown in Fig. 1. Composite profiles for traverse (2) are shown on Fig. 2 and for traverses (3) and (4) on Fig. 3.

RESULTS

Magnetic readings conducted along traverses (1) and (2) show that there are no marked magnetic variations in the general area. However, significant but local magnetic anomalies occur in association with outcropping basic rocks in the Dome.

Along traverse (1) a gravity anomaly (gravity "low") of the order of about 4 milligals was located over the Dome demonstrating that the Dome is cored by rock types of lower density than those surrounding the Dome. Density measurements on selected rock samples generally confirm this.

Along traverse (2) the gravity and surface density measurements again show that the rock formation comprising the Dome are generally of lower density than the surrounding rock formations. A gravity anomaly of approximately 8 milligals occurs on traverse (3) in agreement with the density measurements in the area. Similar results occur in traverse (4).

SUMMARY OF RESULTS

Summing up the geophysical results:

(1) The Blinman Dome is associated with a small but significant gravity "low".

(2) There is no significant regional magnetic anomaly associated with the Blinman Dome.

(3) The density of the basic igneous rock material enclosed in the host breccia in the Dome is significantly higher than all other rock formations occurring both in the Dome and its surroundings.

(4) The longitudinal height profiles across the Blinman Dome show that it is symmetrical in shape.

The results indicate that the rock formations comprising the domal area are of lower density than those comprising the surrounding area and therefore do not support the hypothesis that rock formations comprising the domal area are underlain by large areas of basic igneous rocks.

Two theoretical gravity profiles were computed based on geological information supplied by B. P. Webb, and the following two sets of assumptions were made from the field geological and density measurements.

(1) The domal area is three miles in diameter and comprises a vertical cylinder of density 2·40 g. per c.c., with an outer area surrounding the Dome of density 2·62 g. per c.c. The height of the cylinder comprising the Dome is assumed to be 6,000 feet.

(2) The domal area is three miles in diameter and comprises a vertical cylinder of density 2·50 g. per c.c. with an outer area surrounding the Dome of density 2·62 g. per c.c. The height of the cylinder comprising the Dome is assumed to be 6,000 feet.

In the first case, the computed gravity anomaly is 12 milligals, and in the second case 6 milligals.

Field geological and density measurements suggest that the density of the Dome cylinder is between the limits 2·40 g. per c.c. and 2·50 g. per c.c.,

and therefore the anomaly that should occur would be between the limits 6 and 12 milligals (as measured at the centre of the Dome).

The results are in reasonable agreement with the observed gravity results, as shown in Fig. 4.

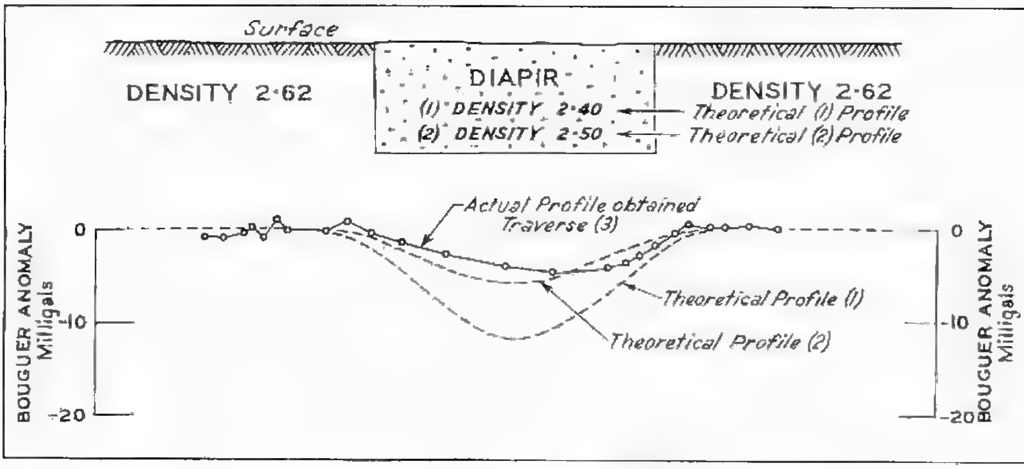

Fig. 4. Comparison of Actual and Theoretical Gravity Profiles.

CONCLUSIONS

The results of the geophysical survey are in agreement with the theory that the Blinman Dome is a diapiric structure, and do not support the theory of the formation of the Dome by the action of a concealed basic plug. Additional magnetic traverses to determine polarity of the larger masses of basic igneous intrusive rocks would assist in determining whether these were intruded along with, or after, the formation of the structure.

ACKNOWLEDGMENTS

The author wishes to thank the Director of Mines for permission to publish this report and to acknowledge the assistance received from J. E. Webb. The assistance of the Drafting Section of the Geological Survey in preparation of the accompanying plans is gratefully acknowledged.

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THE OCCURRENCE OF A SHALLOW GROUNDWATER HORIZON AND ITS NATURAL OUTLETS IN NORTH-EASTERNMOST SOUTH AUSTRALIA

BY H. WOPFNER

Summary

Shallow groundwater occurs on the limbs of anticlines in north-easternmost South Australia. The water, which usually is of good quality, is derived from local intakes and occurs immediately above or at the duricrust horizon. Laterites and lateritic sands overlying the duricrust act as water-bearing strata. Natural springs or seepages are occasionally developed where the contact between duricrust and laterite is exposed down dip on large fold structures. Two such occurrences are described. The Nilpie Springs, situated 20 miles east of Cordillo Downs on the south limb of Cordillo uplift deliver approximately 6,000 gallons of water per day into Nilpie water hole and the Callamurra Seepages, 16 miles east of Innamincka Station, on the southern limb of Innamincka Dome, discharge an estimated 1,000 gallons per day into Callamurra water hole. The importance of this shallow groundwater horizon as a source of good quality water and as an additional feeder for some permanent water holes is emphasised.

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Natural springs or seepages are occasionally developed where the contact between duricrust and laterite is exposed down dip on large fold structures. Two such occurrences are described. The Nilpie Springs, situated 20 miles east of Cordillo Downs on the south limb of Cordillo uplift deliver approximately 6,000 gallons of water per day into Nilpie water hole and the Callamurra Seepages, 16 miles east of Innamincka Station, on the southern limb of Innamincka Dome, discharge an estimated 1,000 gallons per day into Callamurra water hole.

The importance of this shallow groundwater horizon as a source of good quality water and as an additional feeder for some permanent water holes is emphasised.

INTRODUCTION

The area discussed in this paper concerns approximately 2,000 square miles in the far north-eastern corner of South Australia between Cooper Creek and Haddon corner. It comprises some of the most prominent and best developed surface structures in the geological unit known as the Great Australian Artesian Basin. Domes and anticlines greatly influence the occurrence and the distribution of shallow groundwaters whose sources are largely derived from local intake areas. Some of the characteristics of the uppermost water-bearing stratum are subject of the present paper.

The observations were made while the author was engaged in exploration work in the Cordillo area on behalf of Santos Ltd., in 1957-58, and during subsequent visits to the area.

GEOLOGY OF THE "LATERITE" WATER HORIZON

The structures which govern the shallow aquifers are developed in Cretaceous sediments, the exposed strata being members of the Winton formation (Cenomanian) which, in most parts of the area are overlain by Tertiary grits and sands. The top-members of the sequence are invariably silicified and altered to a very hard and tough crust usually referred to as "duricrust". The amplitudes of the fold structures are up to 700 feet with limb dips ranging from 2° to 20°. The tectonic movements responsible for formation of these structures post-dated the development of the duricrust (Wopfner, 1960).

R. L. Jack (1925) who gave a comprehensive account of the occurrence of shallow groundwater in the north-east of South Australia (particularly the area around Cordillo Downs), placed the aquifers of all the shallow wells, e.g.

* Geological Survey, Department of Mines, South Australia.

Nada, etc., within the "upper third of the Desert Sandstone Formation", and consequently, his cross-sections show these aquifers well below the hard, silicified "duricrust".

However, recent investigations by the author have shown that many of these shallow wells are fed by a water-bearing horizon occurring *above* the duricrust.

Due to the development of the broad domal and anticlinal structures which characterise the area, the duricrust frequently forms extensive dip slopes, with prominent erosional remnants forming flat-topped hills in the structural "highs". The dip slopes are covered with younger outwash deposits, commonly made up largely of "gibber" gravels formed from the break down of the duricrust itself. The amount of dip of the duricrust on the southern limb of the Cordillo uplift is shown on Map A in Fig. 1.

Approximately half-way down the dip slopes a lateritic formation can be observed overlying the duricrust, extending down dip into the synclinal areas. (See geological cross-section in Fig. 1.) It is a dark brick-red, nodular (pisolitic) laterite varying in thickness from a thin veneer of a few feet to 120 feet thick and more in the centres of the synclines. Layers and wedges of a red, highly ferruginous, laterised sand and some stringers and lenses of red clay are common throughout the laterite sequence. The base is commonly clayey.

The position of the laterite *above* the duricrust and the continuity of the latter underneath the laterite has been established in several localities in the Cordillo area, and extending into Queensland. It was particularly clearly demonstrated in seismic shot holes across the Haddon Syncline which were drilled in the course of a seismic survey carried out by the Bureau of Mineral Resources in 1957 (Wopfner, 1960). A distinct increase of thickness of the laterite towards the synclines is evident.

The contact between the laterite and the duricrust is either conformable or in form of an erosional disconformity. In the latter case the laterite can rest directly on Cretaceous or Tertiary strata, parts of the duricrust having been removed by pre-laterite erosion. On structures with steeper limb-dips, the contact is unconformable. In some places a thin pebble horizon composed of well-rounded duricrust pebbles occurs between duricrust and laterite. The occurrence of these pebble beds, which might be interpreted as traces of a consequent drainage pattern "in statu nascendi" suggests that the laterite is formed on top of and is younger than the duricrust and therefore is not directly related to the formation of the latter. The author considers that the laterisation process affected late Tertiary to early Pleistocene soils, developed on "post-duricrust" sands and silts.

These laterites, which are extremely porous (15-25 p.c. porosity) and permeable, generally carry a considerable amount of groundwater. The water occurs near the bottom of the laterite, a few feet above the top of the duricrust. The duricrust acts as an impermeable horizon preventing the water from entering deeper strata (see geological cross-section in Fig. 1).

The source of the water is the local intake area situated in the upper parts of the anticlinal limbs, mainly along the contact between duricrust and laterite. The most effective intake conditions exist where consequent streams with a lesser gradient than the existing duricrust dip-slope flow across large exposures of laterite. Water may also enter the laterite anywhere along the dip-slope, but the clayey "gibber-soils" which extensively cover these slopes may tend to reduce the effective intake. (See geological cross-section in Fig. 1).

The quality of the water is very good, provided the horizon is tapped on the structural slopes, where the total salinity very rarely exceeds 50 grains per gallon. Towards the synclines the total salinity increases rapidly. Tables 1

and 2 show the change of the quality of the water in relation to the structural position of the individual well. In both cases the increase of total salinity towards the synclines is evident. (Refer to Map A in Fig. 1 for position of wells mentioned in Table 2. Analyses of Nada and Horseshoe Well are taken from R. L. Jack's paper, 1925.)

TABLE 1.

Name of well	Position of well	Total salinity Grains per gallon
Coppacunda	Westlimb Curallie-Dome, Qld.	36
Tobo	South-west-limb Curallie Dome, Qld.	46
Terrietcha	Haddon Syncline, S.A.	80

TABLE 2.

Well or spring	Nada Well	Nilpie Springs	Horseshoe Well
Date of analysis	19-7-24	29-1-59	19-7-24
Chlorine, Cl	2·10	14·0	65·94
Sulphuric acid (rad) SO_4	7·91	4·2	37·49
Carbonic acid (rad) CO_3	5·10	11·0	11·85
Nitric acid (rad) NO_3	—	trace	—
Sodium, Na	2·96	16·2	53·18
Potassium, K		—	
Calcium, Ca	3·36	1·8	7·72
Magnesium, Mg	1·16	0·7	4·02
Iron, Fe	—	—	—
Silica, SiO_2	5·90		5·80
Total saline matter Grains per gallon	28·49	47·9	186·00
	Assumed composition of salts		
Calcium carbonate	8·40	4·5	19·20
Calcium sulphate	—	—	—
Calcium chloride	—	—	—
Magnesium carbonate	0·08	2·4	0·38
Magnesium sulphate	5·70	—	19·55
Magnesium chloride	—	—	—
Sodium carbonate	—	11·7	—
Sodium sulphate	4·95	6·2	32·32
Sodium chloride	3·46	23·1	108·65
Potassium chloride		—	
Sodium nitrate		trace	
Silica	5·90	—	5·80
	Hardness (English Degrees)		
Total	13·24	7·4	36·08
Temporary	8·48	7·4	19·76
Permanent	4·76	nil	16·32
Due to Calcium	8·40	4·5	19·30
Due to Magnesium	4·84	2·9	16·78

The water-bearing strata are always tapped by means of shallow well-shafts ranging in depth from approximately 50 to 100 feet. This form of development appears to be the most suitable and gives very good pumping supplies. Unfortunately, there are no exact figures available, regarding the supplies of

these wells but as far as the author could gather in conversation with local pastoralists, none of them produces less than 3,000 to 4,000 gallons per day. Most of them are stated to have never been pumped dry by continuous windmill operation. (In 1957, while SANTOS drilling operations were in progress, a daily average of 4,000 gallons was obtained from Terrietcha Well without lowering the water level.)

NATURAL OUTLETS

In two places, the "laterite" groundwater finds a natural outlet, forming springs or seepages. This is significant, when one considers that the area only registers an average annual rainfall of approximately 6 inches.

One such natural outlet, the *Nilpie Springs*, is situated on the southern limb of the Cordillo Uplift (see Map A in Fig. 1) and another, the *Callamurra seeps* occurs on the eastern end of Callamurra Water Hole which is situated on the south-side of Innamincka Dome (see Map B in Fig. 1).

Nilpie Springs

The Nilpie Springs are situated 20 miles ENE of Cordillo Downs homestead on the north-eastern embankment of Nilpie Water Hole in the course of Nilpie Nilpie Creek (see Map A in Fig. 1).

The Nilpie Nilpie Creek is a consequent stream originating on the southern limb of the Cordillo Dome. At the location where the springs occur, the creek has cut deep into the laterite down to the level of the duricrust, forming steep laterite cliffs on its north-eastern side, and exposing the water-bearing horizon. At the base of the cliff face an intricate system of springs occurs over a distance of 200 to 250 feet. There are at least 30 to 40 separate outlets each one showing a small but free flow of clear water, which finally collects in the deepest part of Nilpie Water Hole. (Plate 1, Fig. 1.) The water is discharged from small cavities at the base of the laterite, underlain by a red silty clay (Plate 1, Fig. 2). The layer of clay which attains a thickness of 2 to 3 feet rests directly on top of the duricrust. The cross-section in Fig. 1 illustrates the geological conditions which govern the Nilpie Springs.

The temperature of the spring-water immediately at the outlet was measured. It registered 74° F. at an air temperature (shade temperature) of 102·5 F. An analysis of the water is given in Table 2.

It would be extremely difficult to obtain an exact figure on the total supply of the springs, but the following indirect deduction gives an approximate figure. The author was told by the manager of Cordillo Downs Station, Mr. R. B. Beckwith, that the supply of the springs is sufficient to water a herd of 600 heads of cattle for 12 months. At a daily average consumption of 10 gallons per head and neglecting evaporation, the total supply of the springs would be at least 6,000 gallons per day of excellent water. The supply of the springs remains fairly consistent under drought conditions. The springs themselves can only be observed, when the Nilpie Water Hole has reached a very low level, so exposing the lower cliff-face.

Callamurra Seepages

The Callamurra Seepages occur at the northern embankment of Callamurra Water Hole on the Cooper Creek, about 16 miles east of Innamincka Station (see Map B in Fig. 1). There, the Cooper Creek which in this region usually consists of a multitude of channels, has only one single, narrow channel, cut deep into the duricrust. Being part of the southern limb of the Innamincka Dome (Sprigg, 1959), the duricrust slopes slightly to the south. Fracturing and subse-

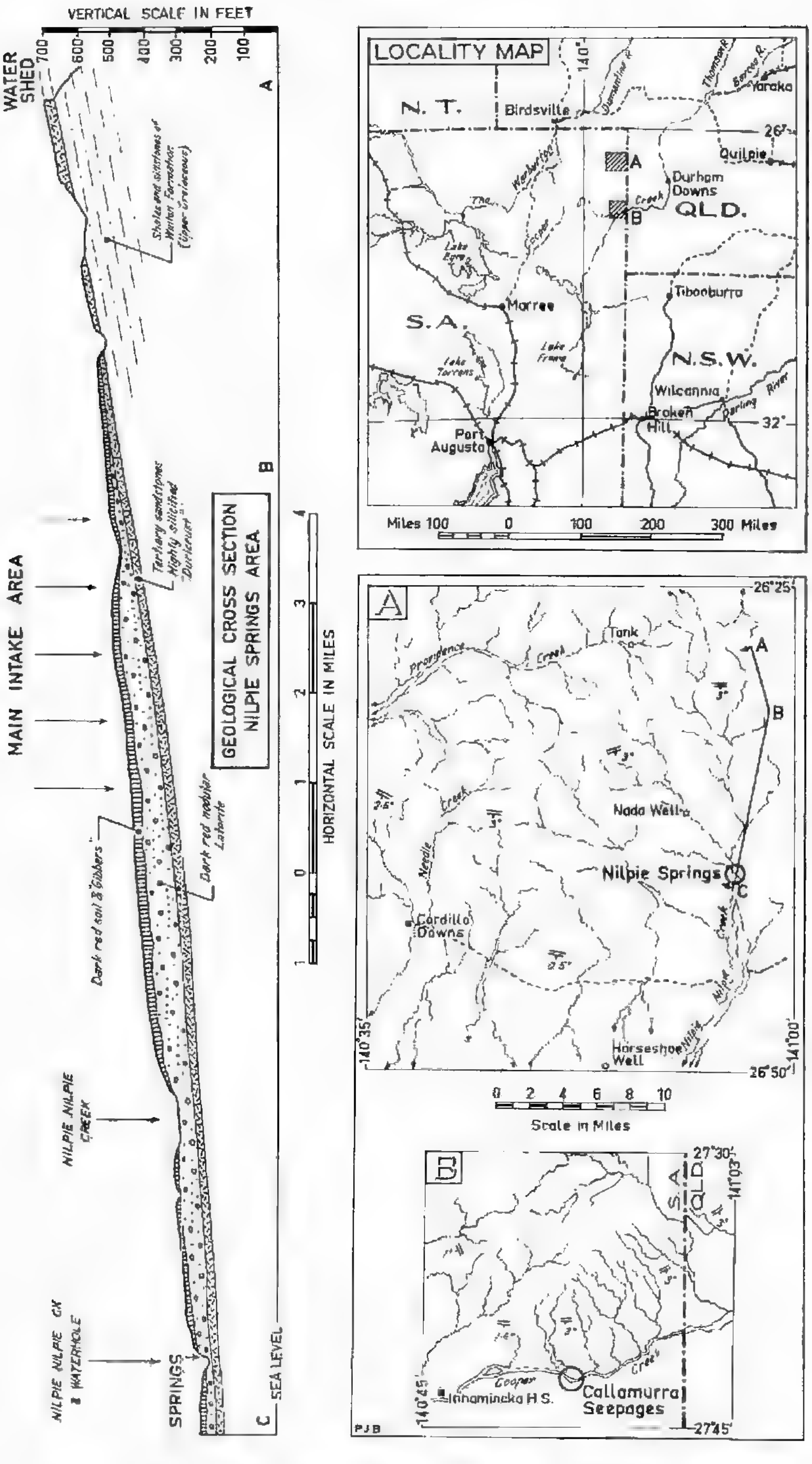

Fig. 1. Locality map showing areas of shallow groundwater occurrence as described in this paper. Insert A shows drainage of Cordillo area and dip of strata. Insert B illustrates dip of strata and drainage north of Callamurra Water Hole (Innamincka area). The position of the geological cross-section A-B-C is shown in insert A.

quent block-weathering has dissected the duricrust extensively, forming deep, narrow cracks, which protrude down to the underlying clays (see Plate 1, Fig. 3).

The water of the seeps extrudes at the base of the duricrust into recent river silts which are deposited against the duricrust. Immediately at the seepages themselves, the laterite has been eroded but is still preserved about 300 feet north.

It appears that the water is carried in the laterite and also in the duricrust where the latter is fractured. The final transport to the seeps takes place within the fractured duricrust.

The seepages occur over a distance of 150 feet and nine individual outlets were observed. The amount of supply of the visible discharge is rather small and was estimated to be about 500 to 1,000 gallons per day. The actual quantity may be considerably larger, as a great amount of the escaping water disappears immediately into the recent river silts.

The intake area is along the southern limb of the Innamincka Dome. As with the Nilpie Springs the groundwater is hydrodynamically controlled by the structural dip. The seeps can only be observed at times of low water level in the Cooper Creek.

CONCLUSIONS

It can be concluded that wherever the duricrusted limbs of prominent structures are blanketed by a reasonable thickness of laterites good pumping supplies of water can usually be obtained. The likelihood of obtaining good supplies of fresh-water will be increased when the location of a new well is positioned down dip from the major intake area. The quality of the water, which is excellent along the slopes, rapidly deteriorates towards the structural "lows". Shallow wells appear to be the most suitable method of developing this groundwater horizon.

Several of the large permanent waterholes in this area occur at a position which is identical to the one described for the natural outlets of the shallow groundwater. It seems highly probable that these waterholes receive additional water via springs and seeps from the laterite groundwater, which could balance the loss incurred by evaporation. The permanency of these water holes could well be due therefore to the additional supply which they obtain from groundwater sources.

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Fig. 1. The northern embankment of Nilpie Water Hole showing the occurrence of the springs along the base of the laterite cliff (left centre of picture) and the spring-water draining down the creek-bed to the water hole. In the foreground the duricrust is covered by recent silt and gravel, but is exposed at the far end of the water hole. Height of laterite cliff approximately 15 to 18 feet.

(*Author's photograph*)

Fig. 2. Two of the individual outlets (points of arrows) of the Nilpie Springs at the base of the laterite. The pisolitic nature of the laterite is illustrated between the two arrows.

(*Author's photograph*)

Fig. 3. The surface of the duricrust at the eastern end of Callamurra Water Hole with typical development of open joints. The seep occurs to the far left of picture.
(Author's photograph)

THE EARLY PRODUCTION BY A. W. HOWARD OF SUBTERRANEAN CLOVER SEED

BY D. E. SYMON

Summary

THE EARLY PRODUCTION BY A. W. HOWARD OF SUBTERRANEAN CLOVER SEED

by D. E. Symon

[Read 11 May 1961]

Subterranean Clover (*Trifolium subterraneum* L.) is the most important sown pasture plant in Australia, now occupying an estimated area of 25-30 million acres (Donald, 1960). It was in South Australia that its agricultural development began and here the first clean seed was sold by Mr. A. W. Howard of Blakiston. Subterranean Clover has the unusual habit of placing its fruiting burrs on or just below the soil surface so that the gathering of the burrs and their threshing presented two distinct problems which had to be overcome before clean seed could be produced.

Hill (1936) states that Howard's attempts to produce seed began about 1900. The dried mature plants were hand raked, chaffed and winnowed, to obtain a relatively clean sample of burrs. It proved impossible to thresh the burrs by flailing and they were eventually hand-rubbed and sieved. Small quantities of seed were cleaned by 1903. Howard persisted in his attempts to improve the method of threshing and with F. I. Dutch eventually built a small two-man huller. With this or other relatively simple machines threshing was continued until after World War I when much larger, more elaborate, tractor-driven hullers were both imported and manufactured locally. At this time, too, the use of horse rakes and rotary brooms for sweeping the burrs together became common. The considerable increase in seed production at this time is reflected in the figures below and in those quoted by Hill for the State.

Miss G. Howard of Blakiston, South Australia, has made available papers of her father, the late A. W. Howard of Blakiston, in which are recorded details of the early sales of subterranean clover seed.

Howard's first letter to the press advocating subterranean clover was to the Adelaide "Advertiser" on February 3rd, 1906, in which a brief but enthusiastic reference was made to the plant. He wrote again to "The Advertiser" on March 2nd, 1906, offering seed to the secretaries of the local branches of the Agricultural Bureau of South Australia. This letter was copied widely in the Australian press and Howard later distributed over 300 packets of seed in response to requests from all over Australia. Ninety-two of these letters requesting seed have been preserved and of these 38 came from Victoria, 33 from South Australia, 10 from New South Wales, three each from Queensland and Tasmania, four from Western Australia and one from South Africa.

Small quantities of seed must have been available at this time, but the first commercial sale was on January 18th, 1907, when Messrs. E. and W. Hackett, an Adelaide firm of seedsmen, bought 30 lb. of clean seed at 2/6 lb. This order was supplied in three lots during January and February which suggests that Howard had little seed on hand and that threshing was slow. Hacketts gave further orders for seed during February-June, 1907, the amounts ranging from 15-44 lb. The only other sales in this year appear to have been 7 lb. to Mr. J. Redcamp, Mayhu, Victoria, and 7 lb. to R. Sewell, another Adelaide seedsman. In this first season about 160 lb. of seed was sold, of which 146 lb. went to Hacketts.

During the 1907-1908 season 624 lb. of seed were cleaned and sold at 2/3 lb. and a single order for 10 lb. of clover burrs was supplied. Hacketts received 602 lb. of the clean seed, the remaining 22 lb. being sold in eight small lots, none greater than 5 lb.

Seed production was further increased during the 1908-1909 season and 1,720 lb. of seed were sold by Howard at 2/3 or 2/- lb. All this seed went to Hacketts except for 40 lb. to two other Adelaide seedsmen. Seed production was more than doubled in the next season (1909-1910) when 3,730 lb. of seed were sold at 2/- per lb. Of this only 926 lb. went to Hacketts, the remainder being widely distributed to buyers from New Zealand, South Australia, Victoria, New South Wales and Tasmania.

Until the 1914-15 season, seed production continued to increase, but only 6 cwt. was recorded as sold for the 1915-1916 season and no records of sales for the two seasons, 1916-1917 and 1917-1918, have survived.

In 1914, the only year of apparently full records during the war, the sale of subterranean clover seed provided more than half of Howard's income. His income was reduced by about 20 per cent. in the next year, 1915, but rose steadily in 1916 and 1917 until it had doubled the 1915 figure by 1918, when the sale of seed again provided more than half of his income. In addition, a record of wages paid by Howard also suggests there was some seed harvested and cleaned during this period.

After the 1914-1918 war, seed production again increased considerably as the threshing machines were greatly improved and there was a strong demand for seed. Many other farmers now began to harvest and distribute seed and Howard's personal contribution was relatively less important.

A summary of his production for the period 1906-1924 is as follows:

Season	Seed Production	Season	Seed Production
1906-07	1·4 cwt.	1915-16	6 cwt.
1907-08	5·5 cwt.	1916-17	No records
1908-09	15 cwt.	1917-18	No records
1909-10	13 cwt.	1918-19	64 cwt.
1910-11	37 cwt.	1919-20	148 cwt.
1911-12	20 cwt.	1920-21	171 cwt.
1912-13	41 cwt.	1921-22	187 cwt.
1913-14	71 cwt.	1922-23	131 cwt.
1914-15	48 cwt.	1923-24	133 cwt.

Finally, it is of interest to compare Howard's production with recent figures for Australia.

Australian production of Subterranean Clover Seed

Season	Tons	Season	Tons
1950-51	2605	1955-56	6236
1951-52	3671	1956-57	4319
1952-53	2432	1957-58	3197
1953-54	3623	1958-59	3100
1954-55	3208		

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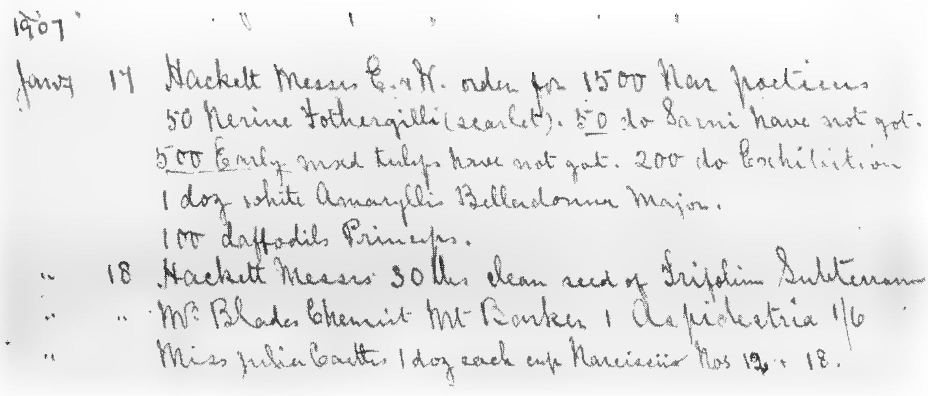

1907

Jany 17 Hackett Messrs E & W. order for 1500 Nar poeticus
50 Nerine Fothergilli (scarlet). 50 do Sarni have not got.
500 Early mxd tulips have not got. 200 do Exhibition
1 doz white Amaryllis Belladonna Major.
100 daffodils Princeps.
" 18 Hackett Messrs 30 lbs clean seed of Trifolium Subterraneum
" " Mr Blades Chemist Mt Barker 1 Aspidistria 1/6
" Miss Julia Carter 1 doz each cup Narcissus Nos 12 & 18.

A photograph of portion of a page in A. W. Howard's order book showing Hackett's original order.

A TAXONOMIC REVISION OF THE GENUS CORREA

BY PAUL G. WILSON

Summary

The genus *Correa* is endemic to Australia and is found in all States. Eleven species are here recognized, three of which are subdivided into varieties. No new species but five new varieties are described; one new varietal name and two new varietal combinations are made. A key to and description of the species and varieties is given.

A TAXONOMIC REVISION OF THE GENUS *CORREA* (*RUTACEAE*)

by PAUL G. WILSON*
(*Communicated by Hj. Eichler*)

[Read 11 May 1961]

SUMMARY

The genus *Correa* is endemic to Australia and is found in all States. Eleven species are here recognized, three of which are subdivided into varieties. No new species but five new varieties are described; one new varietal name and two new varietal combinations are made. A key to and description of the species and varieties is given.

Only a selection of material seen from the following private and public herbaria is cited: C. Beauglehole Herbarium (ACB); State Herbarium of South Australia (AD); Waite Agricultural Research Institute, Adelaide (ADW); Botanic Museum and Herbarium, Brisbane (BRI); C.S.I.R.O., Div. of Plant Industry and Div. of Land Research and Regional Survey, Canberra (CANB); Snowy Mountains Hydro-Electric Authority, Soil Conservation Section (COOMA); Gauba Herbarium, Canberra (GAUBA); Botany School, University of Cambridge (CGE); Bot. Anstalten, Univ. Halle-Wittenberg (HAL); University of Tasmania (HO); C. Ingram Herbarium, Bathurst (INGRAM); Royal Botanic Gardens, Kew (K); National Herbarium of Victoria (MEL); N. A. Wakefield Herbarium, Melbourne (NAW); University of New England, Armidale (NE); National Herbarium of New South Wales (NSW); Dept. of Botany of the University, Sydney (SYD); L. Williams Herbarium, Meningie (WILLIAMS).

INTRODUCTION

The genus *Correa* first became known to science when Joseph Banks and Daniel Solander collected seed and herbarium specimens of it at Botany Bay, May, 1770. The genus was twice described in 1798 within a short period by H. C. Andrews in the Botanists' Repository and apparently independently by J. E. Smith in the Trans Linn. Soc. (as *Corraea*), both of whom named it after the Portuguese ambassador and botanist, Jose Correa de Serra.

The genus is limited to Australia and neighbouring islands and extends from south-east Queensland to Victoria and Tasmania and at least as far west as the Western Australian border. It occupies a variety of habitats ranging from sand dunes on sea coasts and semi-deserts to humid subtropical valleys and alpine streams.

In their natural state all the species except *C. baeuerlenii* show indications of ability to hybridize, at least occasionally, with one or more *Correa* species if growing at the same locality. Besides the more obvious hybrids which are found between two otherwise distinct species one may also find a gradual regional change from one form, variety, or species to another. This topocline is

* State Herbarium of South Australia, Adelaide.

one of the causes of taxonomic confusion within the genus. Thus it is that on the Australian mainland and in Tasmania the various regional forms of *C. reflexa* grade into each other, as similarly does *C. backhousiana* grade into *C. reflexa*. F. Mueller (1860-62), perhaps logically, lumped together all those forms which he could not clearly demarcate, under *C. speciosa*, Bentham (1863) acted similarly, as have most botanists subsequently. No one, since Bentham, has attempted to monograph the genus as a whole. Edwin Ashby (1939) revised the South Australian species but, unfortunately, failed to adhere to the international rules of botanical nomenclature and also overlooked two species already described from South Australian material (*C. pulchella* and *C. schlechtendalii*).

Of the generic synonyms, the earliest, *Mazeutoxeron* Labill., was sunk by Labillardière himself in 1806 (but after Ventenat in 1803) under *Correa* after the prior publication of the latter had been brought to his attention, no author has attempted to reinstate the name. The genus *Antommarchia* Colla ex Meisner was created in order to separate the *C. reflexa* complex from *C. alba*, on the basis of fusion or distinctiveness of the petals, a separation which no one else has followed except at a subgeneric level. Lindley's genus *Didimeria* (1838) was based on the character of the free petals in *C. aemula* being each rolled around two stamens (after anthesis) and of the constant presence of two seeds in each carpel. The latter character is shared by the other species while the petal character although unique within the genus is not of inter-generic distinction.

The genus *Correa* is very clearly defined, no species have been first described under any other genus or have been transferred from *Correa* to other genera (except those now regarded as taxonomic synonyms). It is recognized by its opposite leaves, entirely stellate pubescence, floral parts in fours, sympetalous corolla (at least when young), and glabrous linear stamens. Agardh (1858) considered the genus of sufficient distinctness to create for it the separate family *Correaceae*, but in this he has not been followed by other botanists. The sympetalous corolla has been shown by Hartl (1957) to be due to a secondary fusion, thus it is primarily apopetalous as are most other members of the *Rutaceae*.

According to S. Smith-White (Austral.J.Bot. 2:293(1954)) the chromosome number of *C. alba*, *C. lawrenciana* (probably var. *cordifolia*) and *C. reflexa* ("*C. speciosa*") is n = 16. I have not been able to verify the identity of the specimens referred to by him but I have no reason to doubt his determinations.

Since the genus was first introduced into Europe it has been popular among horticulturalists as a greenhouse plant, and as the species could so readily be artificially hybridized many new cultivars were soon introduced into the gardening world. Some of these were figured and described in horticultural and botanical journals. I have not attempted to search out all names of horticultural plants but in the accompanying index I have listed those which appear in the Index Londonensis and the Index Kewensis, although I have not always been able to see the literature cited nor am I certain that in the reference given the plant was there first described. Where the parentage of the horticultural hybrids was stated I have indicated it within inverted commas after the reference.

The name *Correa* Andr. has been conserved against the name *Correia* Vellozo (1788), a member of the Ochnaceae, which may be considered a homonym. It has also been conserved against *Corraea* Smith, a name which was published in the same year and at about the same time as Andrews', although seemingly independently, and describing the same plant.

CORREA

Correa H. Andrews, Bot.Rep.1:t.18(1 Apr. 1798) nom. cons.; Smith, Trans.Linn.Soc.4:219(1798), "*Corraea*"; Willd., Sp.Pl.2:324(1799); Vent., Jard. Malm. sub t.13 (1803); Desfont., Ann.Mus.Par. 2:32(1803); Persoon, Syn.Pl. 1:419(1805); Labill., Nov.Holl.Pl. 2:120(1806-07); Smith in Rees, Cyclop. 10:(May 1807); Gaertn.K.F., Fruct.Sem.Pl. 3:154(1807); Ait.f., Hort.Kew. ed.2. 2:349(1811); Poir., Tabl.Encycl. 2(6):t.945(1819); l.c. 3(1):606(1823); Edwards, Bot.Reg. 6:t.515(1821); DC., Prod. 1:719(1824); Jussieu, Mem.Mus.Paris 12:478 t.21 f. 22(1825); G.Don, Gen.Hist.Dich.Pl. 1:790(1831); Dietrich, Syn.Pl. 1269(1840); Endl., Gen.Pl. 1156(1840); Hook.f., Fl.Tasm. 1:61(1855); Agardh., Theoria syst.Pl. 229(1858); F.Muel., Pl.Vict. 1:135(1860-62); Benth. et Hook.f., Gen.Pl. 1:294(1862); Benth., Fl.Austral. 1:354(1863); F.Muell., Native Pl.Vict. 1:63(1879), Moore, Fl.N.S.Wales 47(1893); Rodway, Fl.Tasm. 20(1903); Engler, Pflanzenfam. 3(4):144(1896); Bailey, Syn.Queensl.Fl.51(1883); Bailey, Queensl.Fl. 1:195(1899); Black, Fl.S.Austral. 339(1924); l.c. ed.2.495(1948), Engler, Pflanzenfam. ed.2.19a:262(1931); Ewart, Fl.Vict. 694(1931); Ashby, Proc.Linn.Soc.Lond. Sess. 151.214(1939); Hartl, Abh.Akad.Wiss.Mainz, Math.-nat.Kl. Jg. 1957:53-63(1957); Curtis, Students Fl.Tasm. 105(1956). Type species: *Correa alba* Andr.

(For note on priority of publication (Andrews or Smith) cf. Rickett and Stafleu, Taxon 8:299(1959).)

§ *Breviflorae* DC., Prod. 1:719(1824); Sprengel, Syst.Veg. 2:215(1825); G.Don, Gen.Hist.Dichl.Pl. 1:790(1831).

§ *Longiflorae* DC., l.c.; Sprengel, l.c.; G.Don, l.c.

Mazeutoxeron Labill., Voy.Rech.La Perouse 2:11(1800). Type species: *M. rufum* Labill., l.c. 12 Atlas t.17(1800).

Euphocarpus Anders.ex R.Br., Prod. 553(1810) nomen.

Antommarchia Colla ex Meisner, Linnaea 4: Litt. 56(1829); Colla, Hort. Ripul.App. 2:345(1827), nomen.; Presl., Rep.Bot.Syst. 1:185(1834) "*Antomarchia*"; Colla, Mem.Acad.Turin II. 5:492(1843). Type species: *A. rubra* Colla ex Presl., l.c.(1834).

Didimeria Lindl. in Mitchell, Three Exped.E.Austral. 2:197(1838); ed.2, 2:198(1839); Lindl., Ann.Sci.Nat.II. 15:59(1841) "*Didymeria*"; Endl., Gen.Pl. suppl.2, 92(1842) "*Didymeria*"; Walpers, Rep.Bot.Syst. 5:390(1845-46) "*Didymeria*". Type species: *D. aemula* Lindl. in Mitchell, l.c.

Small shrubs to trees up to 30 feet high. Stem, leaves, calyx, and corolla all more or less stellate pubescent at least in the young stage. Leaves opposite, petiolate, chartaceous to coriaceous, entire or variously crenulate, orbicular to narrowly oblong. Inflorescence a small cymose cluster of 1-5 (-7) flowers, terminal on branchlets of 1-several internodes, the terminal pair of foliar organs often variously modified to form obvious bracts. Pedicel with a pair of normally linear or oblong (often minute) bracteoles, these are persistent or caducous from the bud stage, and are inserted from the extreme base to the apex of the pedicel. Calyx more or less cupuliform with the margin entire or four lobed; lobes undulate or denticuliform to lanceolate, occasionally with intermediate lobes. Corolla sympetalous sometimes becoming polypetalous by the early splitting apart of the 4 petals, white or various shades of green or red, lobes valvate. Disc 8-lobed. Stamens 4 + 4, inserted at the base of the disc. Filaments linear usually dissimilar, the antipetalous slightly shorter and with broader basal portions that the antisepalous, glabrous; anthers included or exsert, broadly oblong to lanceolate, with a deep dorsal concavity in which the filament is attached, introrse. Ovary densely hirsute to tomentose or with only apical

tufts of hairs, 4-carpellary, 4-locular. Ovules normally 2 per carpel, superimposed on the axile placenta. Style filiform glabrous or tomentose towards the base, usually more or less equalling the stamens in length; stigma minutely 4-lobed. Fruit splitting into 4 cocci except at the base; cocci axially and apically dehiscing to release the 1 or 2 seeds and cartilaginous endocarp.

Key to species of *Correa*

1. Filaments somewhat dilated at the base; anthers oblong to lanceolate, the margins not recurved after dehiscence; corolla falling after anthesis (except in *C. aemula*).
 2. Calyx ± truncate, if lobed then the lobes dentoid, linear, rounded, or obtusely deltoid. Corolla shades of white, green, or red.
  3. Corolla green or red, over 1·5 cm. long not (or rarely) splitting to the base.
   4. Calyx without lobes between the calyx teeth or if present then small and inconspicuous; plant erect.
    5. Pedicel 3 mm. long or under, bracteoles persistent or caducous, if caducous then corolla red with green lobes or all green and leaves cuneate to rounded (not cordate) at the base; calyx glabrous to densely pubescent, becoming closed immediately after anthesis.
     6. Bracteoles caducous in bud; anthers well exserted; leaves smooth above, chartaceous, rounded to cuneate at the base.
      7. Corolla green, calyx glabrous to tomentose .... 3. *C. glabra*
      7. Corolla red with green lobes, calyx glabrous to sparsely pubescent 2. *C. schlechtendalii*
     6. Bracteoles persistent (caducous in some S. Australian forms); anthers partly to fully exserted; leaves smooth to scabridulous above, cordate (if not cordate then scabridulous above, or coriaceous, or with persistent bracteoles) 1. *C. reflexa*
    5. Pedicel 4-8 mm. long, bracteoles caducous; corolla entirely pale red or green (or if red with green lobes then under 2 cm. long and with coriaceous leaves); calyx glabrous or subglabrous, remaining wide open after anthesis.
      8. Pedicel closely tomentose, not thicker towards the apex; corolla yellowish green, or red with green lobes; anthers 3·5-4 mm. long; leaves dark green.
       9. Corolla less than 2 cm. long, yellowish green or red with greenish lobes. (Islands off coast of S.A., Eyre Pen., and W.A.) 1. *C. reflexa* var. *coriacea*
       9. Corolla more than 2-3 cm. long, yellowish green. (Tasmania and islands.) 6. *C. backhousiana*
      8. Pedicel glabrous or practically so, becoming thicker towards the apex; corolla entirely pale red; anthers 1-1·5 (—2) mm. long; leaves light green, ± glabrous or very sparsely pubescent .... 8. *C. pulchella*
   4. Calyx with prominent deltoid or oblong lobes between the calyx teeth; plant procumbent .... 4. *C. decumbens*
  3. Corolla white or very pale pink, to 1·3 cm. long, becoming split to base 7. *C. alba*
 2. Calyx very deeply 4-lobed, the lobes triangular or lanceolate, acute to acuminate. Corolla greenish.
      10. Pedicel under 0·5 cm. long, corolla remaining sympetalous 5. *C. calycina*
      10. Pedicel over 1 cm. long, corolla becoming split to base 9. *C. aemula*
1. Filaments scarcely broadened at the base; anthers lanceolate with the margins recurved after dehiscence (at least when dry); corolla not falling after anthesis.
      11. Calyx rounded at the base without any protuberance 10. *C. lawrenciana*
      11. Calyx with a patelliform outgrowth at the base 11. *C. baeuerlenii*

1. **Correa reflexa** (*Labill.*) *Vent.*, Jard.Malm. sub.t.13(1803); Persoon, Syn.Pl. 1:419(1805); Labill., Nov.Holl.Pl.Spec. 2:120(1806); K. F. Gaertner, Fruct.Sem.Pl. 3:155(1807); Britten in Banks and Sol., Illust.Austral.Pl. 14(1905); Black, Fl.S.Austral. 340(1924); l.c. ed.2.496(1948); Ashby, Proc. Linn.Soc.Lond.Sess. 151:216(1939); Curtis, Students Fl.Tasm. 106(1956); Court, Vict.Nat. 73:174(1957).

Mazeutoxeron reflexum Labill., Voy.Recherche La Perouse 2:66(1800), Atlas t.19(1800) Type, La baie de L'Aventure, southern Tasmania, ca. 1791, Labillardière (not seen).

C. rubra Smith in Rees, Cyclop. 10:(1807); Smith, Exot.Bot. 2:26(1806) nomen; Banks and Sol., Illust.Austral.Pl. 14. t.34(1905); Black, Fl.S.Austral. 340(1924) p.p.; l.c. ed.2.496(1948); Ewart, F.Vict. 695(1931); Ashby, l.c.(1939). Type, plant described from unpublished plate drawn from material collected by Banks and Solander in 1770 at Botany Bay and named by Solander *C. rubicunda* (= Banks and Sol. l.c. tab.34), corresponding material MEL, NSW.

C. rubicunda Solander ex Britten in Banks and Sol., l.c. pro syn. sub. *C. rubra.*

C. speciosa J. Donn ex Andr., Bot.Rep. 10:t.653(1812); J. Don, Hort.Cantab. ed.6. 100(1811) nomen; Ait.f., Epitome Hort.Kew. addenda 4(1814) nomen; Sims in Curtis, Bot.Mag. 42:t.1746(1815); DC., Prod. 1:719(1824); Spreng., Syst.Veg. 2:215(1825); G. Don. Gen.Hist.Dichl.Pl. 1:790(1831); Dietrich, Syn.Pl. 1269(1840); Walpers, Rep.Bot.Syst. 1:506(1842); F. Muell., Pl.Vict. 1:136(1860-62); Benth., Fl.Austral. 1:354(1863) p.p.; Moore, Fl.N.S.Wales 47(1893); Bailey, Queensl.Fl. 1:196(1899); Rodway, Fl.Tasm. 20(1903); Banks and Solander, Illust.Austral.Pl. 14. t.33(1905). Type figure drawn from plant raised from seed which came from New South Wales.

Antommarchia rubra Colla ex Presl, Rep.Bot.Syst. 1:185(1834); Colla, Hort. Ripul.App. 2:345(1827) pro syn.sub. *C. speciosa*; Colla, Mem.Acac.Turin II. 5:492(1843). Based on *C. speciosa* Andr.

C. speciosa "race" a. *normalis* Benth., l.c. 355(1863), based on *C. speciosa*. Nomen illeg.

"*Antommarchia speciosa* [Andr.] Schlecht.", I.K. 1:157(1893).

C. virens Sm., Exot.Bot. 2:25 t.72(1806); Smith in Rees, Cycl. 10:(1807); Ait.f., Hort.Kew. ed.2. 2:349(1811); Curtis, Bot.Mag. 44:t.1901(1817); DC., Prod. 1:719(1824); Spreng., Syst.Veg. 2:215(1825), G. Don, Gen.Hist.Dichl.Pl. 1:790(1831); Dietrich, Syn.Pl. 1269(1840). Type, figure and description from plant raised by the Marquis of Blandford from seed from "New Holland".

Antommarchia virens (Sm.)Colla, Mem. Acad. Turin II. 5:493(1843).

C. viridiflora Andr., Bot.Rep. t.436(1806); Bonpl., Pl.Rar.Malm. 32-34, t.12(1813). Based on *C. virens* Sm., nom. illeg.

C. speciosa var. *virens* (Sm.)Hook.f., Fl.Tasm. 62(1855); Engl., Pflanzenfam. 3(4):144(1896).

C. rubra var. *virens* [Sm.] Ewart, Fl.Vict. 695(1931) without indication of basionym, nom. illeg.

C. virens Hook., Journ.Bot. 1:253(1835); Walpers, Rep.Bot.Syst. 1:506 (1842). Syntypes, Tasmania: 1831, Lawrence (K); Gunn 152 (K). (However, apparently not intended to be a new species, cf. Hook., Comp.Bot.Mag. 1:276 (1836).)

C. cordifolia Lindl. in Mitchell, Three Exped.E.Austral. 2:231(1838); Lindl., Ann.Sci.Nat. II. 15:58(1841); Walpers, Rep.Bot.Syst. 2:824(1843). Type, near junction of Crawford R. and Glenelg R., south-west Victoria, 24 Aug., 1836, T. L. Mitchell 295 (holo CGE, iso MEL).—Figs. 1, 2.

Shrub 1-4 feet high semiprostrate to erect. Stem closely tomentose to loosely flocculose. Leaves subsessile to distinctly petiolate; petiole 2-5 mm. long; lamina oblong to broadly ovate or orbicular, to 5 cm. long and 3 cm. wide, entire or crenulate, chartaceous to coriaceous, upper surface smooth to scabridulous, glabrous or pubescent, lower surface subglabrous to tomentose, pannose, or flocculose, apex rounded to obtuse, base rounded to cordate with rounded lobes. Flowers erect or pendulous, typically at the end of slender branchlets of one

internode bearing a terminal pair of reflexed leafy bracts and 1-3 flowers on short pedicels (in some forms the branchlets are of more than one internode and the bracts not differentiated from ordinary foliage leaves). Pedicel 2-6·5 mm. long, not swollen above; bracteoles linear, 3-11 mm. long, inserted in the lower half of the pedicel, persistent (or in var. *coriacea* caducous). Calyx semiorbicular, 3-6 mm. high, cream-ferruginous tomentose, more or less truncate or slightly undulate, 4-dentate (sometimes with intermediate lobes), becoming variously folded or flattened after anthesis. Corolla cylindrical to infundibuliform sometimes swollen slightly in the middle, 1·5-3·8 cm. long, closely squamulose, yellowish-green or red with green tips, falling after anthesis. Stamens with the antipetalous filaments broadened and inwardly convex at the base, antisepalous filaments slightly so. Anthers slightly exsert, oblong or ovoid, 2·5-3·5 mm. long (dry) the margins not recurved after dehiscence. Style tomentose towards the base. Ovary densely tomentose to hirsute. Fruit with cocci to 1 cm. long, rounded at the summit, normally not causing the calyx to split.

Key to varieties of *C. reflexa*

1. Flowers subtended by a pair of foliaceous bracts. Bracteoles persistent at least to flowering stage.
   2. Leaves ovate, usually broadly so, base ± cordate or subcordate (or rounded); flowers greenish yellow to red. var. *reflexa*
   2. Leaves narrowly oblong or lanceolate, base rounded; flowers red with green tips.
      3. Calyx 4-dentate; leaves smooth above. (Gippsland.) . . . . var. *cardinalis*
      3. Calyx 4-dentate with 4 inter-rounded to deltoid lobes; leaves scabridulous above. (Grampians.) . . . . var. *reflexa*
1. Flowers not obviously subtended by a pair of foliaceous bracts or if so then with caducous bracteoles.
   4. Leaves coriaceous.
      5. Leaves closely tomentose below, smooth and glabrous above. Flowers less than 2 cm. long; pedicels 5 mm. long or over. S.A. islands; southern Eyre Pen.; Eucla. . . . . var. *coriacea*
      5. Leaves with coarse or fine dense tomentum below, smooth to scabrid above. Flowers over 2 cm. long; pedicels less than 4 mm. long.
         6. Leaves broadly ovate to orbicular. (Islands of Bass Str. and Kangaroo Is.) var. *nummulariifolia*
         6. Leaves narrowly ovate. . . . . var. *reflexa*
   4. Leaves chartaceous . . . . var. *reflexa*

var. reflexa.

Shrub of 2-4 feet high. Stem loosely ferruginous flocculose. Leaves subsessile to distinctly petiolate; petiole 2-5 mm. long; lamina narrowly to broadly ovate (rarely suboblong), 1·5-5 cm. long, 0·6-3 cm. wide, chartaceous (to subcoriaceous in western S. Australia), entire or irregularly crenate, glabrous to sparsely pubescent and usually scabridulose above, thinly tomentose to pannose (rarely subglabrous) beneath, flat or with recurved margin, apex rounded to obtuse, base shallowly to deeply cordate (rarely rounded or obtuse). Flowers 1-3(-5) at the end of lateral branchlets usually of one internode, the terminal foliaceous bracts usually appressed to the pendulous flowers. Pedicel 2-4 mm. long, tomentose; bracteoles narrowly linear, 3-5(-11) mm. long, usually persistent, inserted at or near the base of the pedicel, the lateral flowers of a cluster sometimes with a short peduncle (ca. 2 mm.) and an additional pair of small oblanceolate bracts 2-3 mm. long. Calyx semiorbicular 3-6 mm. high, tomentose, truncate and ± 4-dentate, sometimes with small intermediate lobes. Corolla (1·5-)2-3·5 cm. long green, or red with green tips.

As delimited here this variety is extremely polymorphic but there does not appear to be any natural break between one form and another. Each locality has its own form or forms which grade into each other. The type form from

southern Tasmania has slender peduncles bearing a terminal pair of reflexed foliaceous bracts (from which character it derives its specific epithet) and a pendulous flower with a green cylindrical corolla. Only in the north of the island around Georgetown does a red flowering form occur. On the mainland this typical form is found in New South Wales and Victoria, especially the montane regions, as well as many variations of it.

The red and green forms appear to be intermixed indiscriminately for the most part, although in some cases over large areas only one colour form is found, such is the case in South Australia where east of the Mt. Lofty Ranges to the Victorian border only red flowered forms occur.

As is discussed under *C. alba*, it appears that the type of *C. rubra* is a hybrid between *C. alba* and *C. reflexa*, both species grow near together at the type locality, Botany Bay. Putative hybrids between the two species have also been found along the south coast of Victoria.

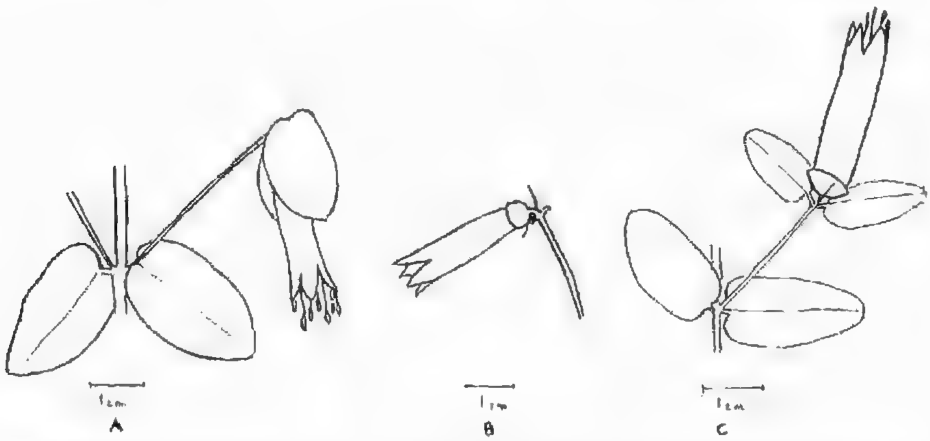

Fig. 1. *Correa reflexa* var. *reflexa*: A, typical form from Uriarra, A.C.T. (Pullen 2087); B, same with bracts removed; C, form found around Botany Bay (NSW 51571).

A form with thin white tomentose leaves and green flowers occurs at the Encounter Bay region of Fleurieu Peninsula and as is discussed under *C. calycina* it appears to be in the nature of a hybrid swarm between that species and *C. reflexa* with possibly the influence of other species.

C. reflexa var. *reflexa* grades into the other varieties and the distinctions made in this paper between them are possibly not entirely natural.

The type plate of *C. speciosa* agrees well with specimens of *C. reflexa* gathered from the area around Botany Bay.

Distribution: S.E. Queensland, eastern New South Wales, Victoria, Tasmania, southern regions of South Australia.

QUEENSLAND, south-east. Darling Downs: Crows Nest, *C. White* (BRI, NSW); Mistake Plateau to Castle Mt., 3100 ft., "shrub 3 ft.", *Goy and Smith* 467(BRI); Mt. Ernest, 2500-3000 ft., *C. White* 8578(BRI); Stanthorpe, *J. Boorman* (NSW); Wallangarra, *anon.* 105(BRI); Wyberba, *C. White* 9340(BRI).

NEW SOUTH WALES. Abercrombie Caves, "3-4 ft.", *E. Constable* (AD); Apsley Falls, *L. Johnson* (NSW); Armidale, *M. Cumston* 10(NSW); Barrington, "2 ft.", *E. Hyem* 11 (NSW); Burrill Lake, *M. Tindale* (AD); Brush Is., *F. Rodway* 1211(NSW); Bundanoon, *J. Williams* (NE); Bundeena, *R. Oxenford* (NSW); Burrinjuck Dam, *R. Straatmans* (CANB); Botany Bay, 1770, *Banks and Solander* (MEL, NSW); ibid., Kurnell, *J. Boorman*

(NSW); Concord, *O. Evans* (CANB); Clyde Mt., *J. Boorman* (NSW); Cambewarra, *W. Baeuerlen* (MEL); Cessnock, *C. Ingram* (INGRAM); Disaster Bay, *E. Constable* (NSW); East Burnerong, *G. Chippendale* (NSW); Goulburn, *C. Moore* (MEL); George, R., Campbelltown, *N. Ford* (NSW); Gladesville, *J. Boorman* (NSW); Guyra, *R. Mulligan* 1(NSW); Gloucester Buckets, *J. Boorman* (NSW); Jenolan Caves, *Blakely* (NSW); Kurri Kurri, *D. Dunning* (NE); Kurrajong Mts., *J. B. Cleland* (AD); Mudgee, *W. Woolls* (MEL); Merimbula-Pambula, *F. Rodway* 1208(NSW); Mt. Dromedary, *E. Reader* 1(MEL); Mt. Jellore, *E. Cheel* (NSW); Milton, *J. Boorman* (NSW); Mt. Kaputar, 5000 ft., *C. Ingram* (INGRAM), Moonbi, *N. Burbidge* 2847(CANB); Mt. Kosciusko, near base, *F. Mueller* (MEL); Narrabeen, *M. Day* (CANB); Newcastle, *L. Leichhardt* (NSW); Namoi, *Nusson* 92(MEL); Nowra, *F. Rodway* 1202(NSW); Olney State Forest, *E. Constable* (NSW); Pt. Stephens, *C. Davis* 14(NSW); Peak Hills, Harvey Ranges, *J. Boorman* (NSW); Pambula, *M.M.* 2271 (COOMA); Red Head, *F. Rodway* (NSW); Sussex Inlet, *J. Vickery* (AD); Squatting Rock Gap, Mt. Colong, 2500 ft., *J. Garden* (NSW); South Kincumber, *G. Chippendale* (NSW); Taree, *W. de Beuzeville* 16(NSW); Tascott, *R. Scott* (NE); Torrington, *J. Boorman* (NSW); Talbingo, *Althofer* 946(COOMA); Tumut, *Maiden* (BRI, NSW); Twofold Bay, *Gauba* (GAUBA); Tabourie Is., *F. Rodway* 1212(NSW); Warrumbungle Range, *G. Althofer* 34(MEL); Ubarby, *C. Ingram* (INGRAM); Ulan, 1200 ft., *L. Johnson* (NSW); Widden, *E. Constable* (NSW); Warialda, *J. Boorman* (NSW); Wentworth Falls, nr. Katoomba, *F. Hutton* (AD).

A.C.T. Punchbowl Ck., *A. Gray* 4594(CANB); Murrumbidgee R., *W. Hartley* 48 (CANB); Uriarra, *Gauba* (GAUBA), Weetangera, *R. Pullen* 2115(CANB); Jervis Bay, *Gauba* (GAUBA); Bowen Is., Jervis Bay, *F. Rodway* 1204(NSW).

VICTORIA. Amherst, *J. A. Smith* (MEL); Brighton, *F. Mueller* (MEL); Bendigo, *C. Sutton* (MEL); Buchan R., *F. Mueller* (MEL); Buffalo Ranges, *F. Mueller* (MEL); Buring, *F. Reader* (MEL); Bridgewater, *C. Beauglehole* 5106(ACB); Bendigo, *C. Beauglehole* 5124 (ACB); Upper Cann R., *N. Wakefield* 4605(NAW); Doncaster, *G. Toepffer* 6(MEL); Daylesford, *R. Wallace* (MEL); Dimboola, *C. E. D'Alton* (MEL); Fainting Range, 1883, *A. Howitt* 4(MEL); Forest Ck., Castlemaine, *Bunce* (MEL); Glenelg R., Mt. Kincaid, *M. Allitt* (MEL); Genoa R., Sept. 1860, *F. Mueller* (MEL); Gabo Is., *Maplestone* (MEL); Hume R., *S. Jephcott* (MEL); Halls Gap, Grampians, *Burford* (AD); Inglewood, *E. Nolan* (MEL); Lakes Entrance, Gippsland, *J. Stirling* 137(MEL); Mt. Dandenong, *P. St. John* (MEL); Mallacoota, *T. Hart* (MEL); nr. Mt. Hotham, 5000 ft., *Mrs. M'Cann* (MEL); Meredith, *S. Johnstone* (MEL); Murrungowar, 1000 ft., *N. Wakefield* (NAW); Maryborough, *C. Maplestone* (MEL); Nhill, *C. Walter* (MEL); Orbost, *N. Wakefield* 3546 (NAW); Plenty Ranges, Oct. 1852, *F. Mueller* (MEL); Research, 2 Jun. 1947, *Gauba* (GAUBA); Station Peak, nr. Geelong, *J. E. Main* (MEL); Smythesdale, *C. Collyer* (MEL); Sealers Cove, Wilsons Prom., *F. Mueller* (MEL); Stawell, *J. Staer* (NSW); Tyrendarra to Surry R., Portland, *H. Aston* 698(AD), Victoria Range, *Finck and Beauglehole* (MEL).

BASS STRAIT. Flinders Is., *L. Rodway* (NSW); King Is., *C. French Jr.* (NSW).

TASMANIA. Avoca, South Esk R., *C. Stuart* (MEL), Coles Bay, Fleurieu Bay, *Rodway* (CANB), East Arm, *C. Stuart* (MEL); Freycinet Pen., *R. Black* (MEL); Georges Bay, *A. Simpson* (BRI), Glenorchy, 1000 ft., *F. Long* 196(CANB); George Town, *R. Gunn* (NSW); Glen Leith, *R. Gunn* 1030(NSW); Kingston, *W. Curtis* (HO); Lindisfarne, *R. Black* (MEL); Low Head, *R. Rupp* (NSW); Launceston, *C. Stuart* 23(MEL); Mt. Direction, *F. Rodway*, 1201(NSW); Mt. Wellington, *R. Black* (MEL); Mt. Nelson, *R. Black* (MEL); Montrose, *F. Long* 437(CANB); New Town rivulet, *W. Weymouth* 29(MEL); N. Esk, *R. Gunn* 152(NSW); Penguin, *R. Gunn* (NSW); Port Sorel, *C. Stuart* 970(MEL), Sandy Ck., *C. Stuart* 238(MEL); "Neighbourhood of the Derwent", *R. Brown* (MEL).

SOUTH AUSTRALIA. Arno Bay, *E. Ising* (AD); nr. Bucklebooo, *K. Rohrlach* 771(AD); Bakers Range, *J. Green* 247(AD); Clarendon, *J. Tepper* (MEL); Cape Banks, *J. B. Cleland* (AD); Cape Douglas, *T. Lothian* (AD); Coonalpyn, *H. Andrew* (AD); Cummins, *J. Cleland* (AD); Coorong, nr. Salt Ck., *D. Whibley* 111(AD), Carapee Hill, *K. Rohrlach* 462 (AD), Encounter Bay, *J. B. Cleland* (AD); Gawler Range, *E. Ising* (AD); Hawkes Nest, Malinong, *M. Sharrad* 529(AD), Keith to Bordertown, *M. McLaren* (INGRAM); Kuitpo, *A. Morris* (ADW); nr. Keith, *R. Specht* and *Rayson* 41(AD); Lacepede Bay, *H. Babbage* (MEL), Lake Bonney, 1874, *Mrs. Wehl* (MEL); Meningie, *L. Williams* 638(WILLIAMS); Mt. Burr, *R. Crocker* (ADW), Marble Ranges, *C. Wilhelmi* (MEL); Mt. Magnificent, *R. Schodde* 753(AD); Naracoorte, *Mrs. Petherick* (AD); Onkaparinga to Willunga, *F. Mueller* (MEL); Pt. Lincoln, *A. Adcock* (AD); Pt. Pirie, *M. Koch* 758(NSW); Pt. Elliot, *Miss Hussey* 122(MEL); Pt. Vincent, *J. Black* (AD); Rapid Bay, *F. Mueller* (MEL); Rivoli Bay, *F. Mueller* (MEL); Spalding Cove, *P. Wilson* 308(AD); Sandy Ck., Gawler, *J. Cleland* (AD); Tintinara, *J. W. Green* 1838(AD, NE); The Springs, Mt. Gambier, *E. Ising* (AD); Kangaroo Island, Kingscote, *R. Rogers* (AD), Kelly Hill, *P. Wilson* 703(AD); Hog Bay, *L. E. Clarke* (AD); Penola, *W. Gill* (NSW); Willson R., *J. Willson* (NSW).

C. REFLEXA × ?

"Encounter Bay" form

SOUTH AUSTRALIA. Southern Fleurieu Peninsula and Encounter Bay: Boat Harbour Ck., *Hj. Eichler* 14426(AD); Callawonga Ck., *F. Hilton* (ADW); Deep Ck., *E. Jackson* 8(AD); Goolwa, *J. B. Cleland* (AD); Tunkalilla Beach, *J. B. Cleland* (AD, MEL); Tapanappa Ck., *Hj. Eichler* 14478(AD); Willow Ck., Waitpinga, *J. B. Cleland* (AD).

Fig. 2. Distribution of *Correa reflexa* var. *reflexa* ●; var. *cardinalis* ×; var. *coriacea* +; var. *nummulariifolia* ○.

CORREA REFLEXA [× DECUMBENS ?]

VICTORIA. Grampians: *C. Walters* (NSW); ibid., *R. Baker* (AD, MEL); ibid., *Gauba* (GAUBA); ibid., *F. Robbins* (ACB); ibid., *Finck and Beauglehole* (ACB); ibid., *A. Hicks* (ACB); ibid., *D. Symon* 37(AD, ADW); ibid., *M. Singleton* (MEL); Burneys Ck., *J. Willis* (MEL); Mt. Victoria, *E. H. Ising* 2324(AD); Murra Warra, *F. Mueller* (MEL); Pomonal, *J. Starr* (NSW); Stawell, *A. Tadgell* (MEL); Stony Ck., *A. Tadgell* (MEL); Victoria Range, *Finck* and *Beauglehole* (MEL).

var. **cardinalis** (*FvM. ex Hook.*)*Court*, Vict.Nat. 73:175(1957).

C. cardinalis FvM. ex Hook., Bot.Mag. 92:t.4912 (1 Apr. 1856); F. Muell., First Gen.Rep. 10(1853) nomen; anon., The Florist, 187(June 1856) nomen, et 225 t.116 (Aug. 1856); Fl.des Serres II. 1:t.1144(1856); Hannaford, Jottings in Australia 41(1856)p.p.; Ill.Hort. t.102(1856); Parey's Blumengaertnerei 1:847 (1931). Type, figure drawn from plant raised from Australian seed by Veitch and Son. "Our Herbarium shows the plant [i.e. that raised from seed] to be identical with *Correa cardinalis* of Dr. Ferdinand Mueller, . . . and which he discovered 'about the Latrobe River, in sandy, bushy places of the hills, and in the sterile plain of Port Albert, Gipps' Land, Colony of Victoria, South Australia'." Hook. l.c. Syntypes: "In virgultis collium arenos. inter fl. Latrobe and Merrimans creek", 26 Apr. 1853, F. Mueller (MEL); "Sandy scrubland near Port Albert", May 1853, F. Mueller (MEL).

C. speciosa f. *cardinalis* (FvM. ex Hook.)Voss, Vilmorin's Blumengaertnerei ed.3. 1:170(1894-1896).

Shrub 1-2 ft. high. Leaves narrowly to broadly oblong or slightly lanceolate, from 2 cm. long and 0·8 cm. wide to 4 cm. long and 0·4 cm. wide, glabrous and smooth above, tomentose beneath, margin minutely undulate, slightly recurved,

apex obtuse to rounded, base rounded to subcordate. Flowers normally terminal on slender lateral branchlets of one internode. Calyx suborbicular, truncate, 4-dentate, ferruginous tomentose. Corolla ± cylindrical, 3·0-3·8 cm. long, red with green tips. Anthers just exserted.

This variety is distinguished by its oblong leaves and relatively large red corolla. In the Grampians of western Victoria occurs a similar plant but with the leaves scabrid on the upper surface and the calyx with 4 deltoid to rounded processes between the normal calyx lobes. This form is very variable and appears to be in the nature of a hybrid swarm between *C. reflexa* and *C. decumbens* although the latter has not yet been recorded from Victoria.

Distribution: Gippsland, south-east Victoria.

VICTORIA. Dutson, nr. Sale, *P. St. John* (MEL); Hedley, nr. Pt. Albert, *A. Tadgell* (MEL); Latrobe R., *Purdie* 108(MEL); Port Albert, *F. Mueller* (MEL); Taralgon, *F. St. John* (MEL); Toora, nr. Foster, *A. Tadgell* (MEL); Yarram, *J. W. Audas* (MEL); South Gippsland, *W. H. Lucas* 1(MEL).

var. **nummulariifolia** (*Hook.f.*) comb.nov.

C. speciosa var. *nummulariifolia* Hook.f., Fl.Tasm. 1:62(1855). Type, Flinders Island, Bass Strait, J. Backhouse (not seen).

C. rubra var. *orbicularis* Black, Fl.S.Austral. ed.2. 496(1948) without a Latin diagnosis, nom.illeg.

[*C. speciosa* [race] b. *backhousiana* auct. non (Hook.) Benth.: Benth., Fl. Austral. 1:355(1863)p.p.]

Leaves broadly ovate, semiorbicular or orbicular, coriaceous, glabrous or somewhat pubescent above, tomentose to pannose below. Flowers 1-3 at the end of short branchlets of 1-3 internodes. Peduncle and bracts not differentiated. Pedicels 2-4 mm. long; bracteoles, linear, caducous, inserted near the base of the pedicel. Calyx ferruginous tomentose.

This variety varies considerably in leaf indumentum, texture and shape. The flowers also vary from cylindrical to infundibuliform and from greenish yellow to red. Although this creates a polymorphic taxon, I am broadening Hooker's concept of the variety to include the form designated by J. M. Black as "*C. rubra* var. *orbicularis*", a name never validly published. In Kangaroo Island it appears to take part in a hybrid swarm between *C. pulchella*, *C. decumbens*, and *C. reflexa* var. *reflexa*.

Distribution: From Flinders Island (Bass Strait) westward to Kangaroo Island. An island variety.

BASS STRAIT. Flinders Is., 1952, *D. Sleane* 2445(HO); ibid., *anon.* 695(MEL); Furneaux Group, 1893, *J. Gabriel* (MEL); Deal Is., 1889, *Judge Dobson* (MEL); Mt. Munro, Cape Barren Is., 1891, *Bishop of Tasmania* [*Henry Montgomery*] (MEL).

KANGAROO ISLAND. American R., *W. Wade* (AD); Birchmore Lagoon, *P. Wilson* 891 (AD); Cape du Couedic, *J. B. Cleland* (AD); Cape Borda, *J. B. Cleland* (AD), Hog Bay, *J. Maiden* (NSW); Hanson Bay, *P. Wilson* 834(AD); Kingscote, *G. Beck* (AD); Kelly Hill, *P. Wilson* 708(AD); Muston, *H. Cooper* (AD); McGillivray, *C. M. Eardley* (ADW); Pennington Bay, *D. Symon* (ADW); Remarkable Rocks, *J. B. Cleland* (AD); Rocky River, *R. Rogers* (NSW); Vivonne Bay, *J. B. Cleland* (AD); West Bay, *P. Wilson* 946(AD); Kangaroo Island, Feb. 1802, *R. Brown* (BRI, MEL, NSW).

var. **coriacea** nov.var.

[*C. alba* auct. non Andr.: Black, Fl.S.Austral. 340(1924) p.p.; l.c. ed. 2. 495(1948) p.p.]

Folium petiolus 3·5-6 mm. longus; lamina coriacea, integra, supra glabra, levis, infra dense et minute tomentosa, late ovata vel orbicularis, basi rotundata vel truncata. Pedicellus 5-6·5 mm. longus, bracteolis caducis prope basem insertis. Calyx truncatus, dense et minute tomentosus. Corolla 1·5-1·7 cm. longa, viride-flava vel rubra. (Holotypus, North Pearson Is., 14 Feb. 1960, R. L. Specht 2102(AD).)

Bush to 3 feet high. Leaves with petiole 3·5-6 mm. long; lamina broadly ovate to orbicular, smooth and glabrous above, closely and finely tomentose below, apex ± rounded, base rounded to truncate. Inflorescence without differentiated peduncle or bracts. Flowers terminal on short branchlets of indefinite length. Pedicel finely and closely tomentose, 5-6·5 mm. long; bracteoles caducous inserted towards the base of the pedicel. Calyx truncate, closely and finely tomentose. Corolla 1·5-1·7 cm. long, greenish-yellow to red, sometimes becoming split to the base. Style tomentose towards the base.

This variety closely approaches, on the one hand, *C. backhousiana*, and on the other the S. Australian mainland form of *C. reflexa* var. *reflexa*. *C. backhousiana* has similar leaves, indumentum, and a well-pronounced pedicel with caducous bracts, it possesses, however, a larger corolla of rather different shape and the calyx is usually undulate on the margin. The S. Australian mainland form of var. *reflexa* has larger flowers than var. *coriacea*, with shorter pedicels, the indumentum and leaf shape is also very different although intermediate forms occur on Eyre Peninsula and Yorke Peninsula. The var. *nummulariifolia* differs in having a shorter pedicel and larger flowers, and also in the coarser indumentum on stem, leaves and flowers.

This variety is interesting in being the only form of *Correa* found in Western Australia and then from only just within the border (between Eucla and Wilsons Point). The record by Bentham in Fl.Austral. 1:354(1863) under *C. speciosa* of "King George's Sound, Maclean" (which record is also referred to by J. D. Hooker in Fl.Tasm.), I have not been able to confirm, the Perth Herbarium have no record of *Correa* occurring in their State, and I have seen no specimens from the King George's Sound area, but I see no reason why it might not be present there.

The var. *coriacea* could be as well considered a variety or form of *C. backhousiana* as of *C. reflexa* since it grades imperceptibly into both species, yet the recognition of its status does separate off an on the whole well-marked variety. I have been unable to ascertain the nature of the calyx after anthesis, but because it is fairly coriaceous it may remain partially open.

Distribution: The islands off the west coast of South Australia; southern Eyre Peninsula; and near Eucla, south-east point of Western Australia.

SOUTH AUSTRALIA. Eyre Peninsula: Memory Cove or Pt. Lincoln area, Feb. 1802, *R. Brown* (BRI); Port Lincoln, *J. G. O. Tepper* (AD); South Pearson Is., *T. Osborn* (AD, NSW); North Pearson Is., *R. L. Specht* 2100, 2101(AD); Isle St. Francis, 3-4 Feb. 1802, *R. Brown* (MEL, NSW); Greenly Is., *Adelaide Bushwalkers* (AD).

WESTERN AUSTRALIA. Eucla, 1884, *P. Olivier* (MEL); Wilsons Bluff, 11 Feb. 1879, *R. Tate* (AD).

2. **Correa schlechtendalii** *H. Behr*, Linnaea 20:630(1847); Walpers, Ann.Bot. Syst. 1:155(1848). Type, Stony scrubland, South Australia, H. Behr 139 (holo HAL).

[*C. speciosa* [race] d. *glabra* auct. non (Lindl.) Benth.: Benth., Fl.Austral. 1:355(1863) p.p.]

[*C. rubra* var. *glabra* auct. non (Lindl.) Black: Black, Fl.S.Austral. 340 (1924) p.p.]

C. turnbullii Ashby, Proc.Linn.Soc.Lond.Sess. 151: 219, 220(1939). Type, near Monarto South, Murray Mallee, South Australia, E. Ashby (holo AD).

C. rubra var. *turnbullii* (Ashby) Black, Fl.S.Austral. ed. 2. 496(1948).—Figs. 3B, 4.

Shrub to 6 feet high. Young branches sparsely ferruginous tomentose. Leaves with petiole 3-5 mm. long; lamina narrowly to very broadly elliptic or almost oblong, 1·7 cm. long and 1·2 (-1·5) cm. wide to 4·5 cm. long and 0·8

cm. wide, chartaceous, glabrous above, glabrous or sparsely pubescent below, apex rounded, base rounded to cuneate. Flowers solitary, terminal on lateral branchlets of 3-4 internodes. Peduncle not differentiated, bracts (i.e. terminal foliar members) either foliaceous and persistent or oblong, 3-4 mm. long, and usually caducous. Pedicel slightly pubescent, not thickened above, 3-4 mm. long; bracteoles linear, 2-3 mm. long, caducous, inserted at or near the base of the pedicel. Calyx campanulate, 4-6 mm. long, sparsely pubescent or glabrous, margin ± entire and 4-denticulate, rarely irregular, becoming flattened after anthesis. Corolla infundibuliform to cylindrical, 1·6-2·8 cm. long, red with green lobes, deciduous in fruit. Staminal filaments broader at the base; anthers narrowly oblong 2·6-3·3 mm. long (dry), the margins not recurved after dehiscence, well exsert to about ⅛ to ⅕ the length of the corolla. Fruit to 8 mm. high, the cocci rounded above, not causing the calyx to split.

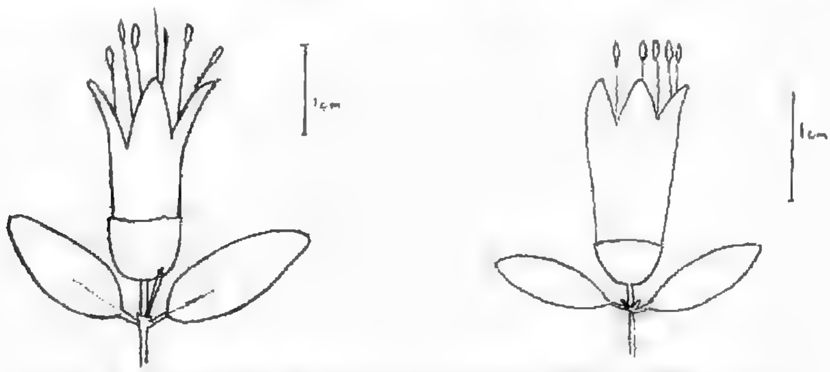

Fig. 3. A, *Correa glabra* (Mt. Talbareeya, NSW 30228); B, *C. schlechtendalii* (Chaunceys Line, Eichler 12394).

This species may be recognized by the elliptic subglabrous leaves and by the position, shape, and colour of the flower. It appears to be closely related to *C. glabra*, and intermediates between the two species are found in the Torrens Gorge of the Mt. Lofty Ranges where they both occur.

Distribution: Mt. Lofty Ranges to Murray scrub; and occasional in southern Flinders Range, South Australia. Extreme north-west Victoria.

VICTORIA. Dimboola and Nhill, *St. E. D'Alton* (AD, MEL).

SOUTH AUSTRALIA. Black Springs, *D. Symon* (ADW); Burra (ADW); Cudnaka (i.e. Kanyaka), Oct. 1851, *F. Mueller* (MEL); Chauncey's Line, Monarto South, *Hj. Eichler* 12394(AD); Cooke Plains, *M. Sharrad* 573(AD); Coonalpyn, *J. B. Cleland* (AD); Emu Downs, Burra, 1931, *Hoff* (AD); Eden, *E. H. Ising* (AD); Halls Ck., *F. Mueller* (MEL); Humbug Scrub, *Hj. Eichler* 12205(AD); Julia Range, *P. Wilson* 1021(AD); Kulde, *E. H. Ising* (AD); Karoonda, *J. B. Cleland* (AD); Kimchina, *E. H. Ising* (AD); Lameroo, *R. Hill* 1010(AD); Lowan Stn., nr. Sherlock, *Chinnick* (CANB); Malinong, *L. Williams* 667(WILLIAMS); Mannum, *J. B. Cleland* (AD); Mt. Beevor, Mt. Lofty Ranges, Feb. 1848, *C. Stuart* (MEL); Mt. Barker, Sept. 1848, *F. Mueller* (MEL); Murray Bridge, *J. M. Black* (AD); Nairne, *E. H. Ising* (AD); "North Rhine River" (i.e. Somme River), Dec. 1850, *F. Mueller* (MEL); Parilla Forest, *W. Gill* (NSW); Telowie Gorge, *E. Jackson* 1(AD); Torrens Gorge, *J. Black* (AD); Tailem Bend, *E. H. Ising* (AD); Wynarka, *E. H. Ising* (AD); Yumali, *L. D. Williams* 830(AD, WILLIAMS).

3. **Correa glabra** *Lindl.* in Mitchell, Three Exped.E.Austral. 2:48(1838); Lindl., Ann.Sci.Nat. II. 15:58(1841); Walpers, Rep.Bot.Syst. 2:824(1843). Type, between Mt. Warraway and Hillston, Lachlan district, New South Wales, 21 Apr. 1836, T. L. Mitchell 84 (holo CGE, iso MEL).

C. lawrenciana var. *glabra* (Lindl.)Hook.f., Fl.Tasm. 1:62(1855) not as to specimen cited.

C. speciosa [race] d. *glabra* (Lindl.) Benth., Fl.Austral. 1:355(1863) p.p

C. speciosa var. *glabra* (Lindl.) Maiden et Betche, Census N.S.Wales Pl. 117(1916).

C. rubra var. *glabra* (Lindl.) Black, Fl.S.Austral. 340(1924) excl.desc.

C. reflexa var. *glabra* (Lindl.) Court, Vict.Nat. 73:175(1957).

C. leucoclada Lindl. in Mitchell, l.c. 39(1938); Lindl., Ann.Sci.Nat. II. 15:58 (1841); Walpers, Rep.Bot.Syst. 2:824(1843). Type, Summit of Goulburn Range, New South Wales, 29 Apr. 1836, T. L. Mitchell 106 (holo CGE, iso MEL ?).

C. speciosa [race] c. *leucoclada* (Lindl.) Benth., l.c. (1863).

C. speciosa var. *leucoclada* (Lindl.) Maid. et Betche, l.c. (1916).

C. rubra var. *megacalyx* Black, Fl.S.Austral. ed. 2. 496(1948) without a Latin diagnosis, nom. illeg.—Figs. 3A, 4.

Bush to 9 feet high. Young branches grey to ferruginous tomentose or sub-glabrous. Leaves with petiole 2-4 mm. long; lamina narrowly to broadly elliptic (or occasionally sub-ovate or obovate), entire, 1-4 cm. long, 0·5-1·7 cm. wide, glabrous or sub-glabrous above, glabrous to tomentose or flocculose below, apex obtuse to rounded, base cuneate to rounded. Flowers solitary, terminal on short axillary shoots which bear usually 2 pairs of leaves. The peduncle and bracts are not differentiated. Pedicel glabrous or pubescent, not enlarged above, 2-4 mm. long; bracteoles basal, linear to oblanceolate, 4-7 mm. long, caducous or persistent. Calyx shallowly to deeply cupuliform (3-)4-6(-10) mm. long, ca. 5(-8) mm. broad, glabrous to tomentose on the outside, ± truncate, lobes minute; calyx becoming flattened and closed after anthesis. Corolla cylindrical to infundibuliform 1·5-3 cm. long, pale green, lobes erect or recurved, deciduous in fruit. Staminal filaments broadened at base; anthers exserted to about ⅕ to ⅙ the length of the corolla (1·5-)2·5-3·5(-4) mm. long, ± narrowly oblong, the margins not recurved after dehiscence. Style glabrous to tomentose below, ovary tomentose. Fruit white, apex of cocci rounded, to 7·5 mm. long, not causing the calyx to split.

This is again a very variable species. Lindley distinguished two species, his *C. leucoclada* being a more densely tomentose form but otherwise very similar. The great variability in the sizes of the anthers, corollas, and calyces suggest that some subspecific distinctions could be made, however, there are all intermediates between the extremes. It may be distinguished from its closest ally, *C. schlechtendalii*, by its green not green and red corolla but otherwise some forms of the two species are very similar. Except for one locality in the lower Mt. Lofty Ranges, South Australia, their areas of distribution do not overlap, at that point where the two appear to meet all intermediates between them may be found. From *C. reflexa* it may be distinguished by the leaf shape and absence of bracts and peduncle; the calyx is also of a different shape, usually deeper and less tomentose.

At Barwon Falls near Geelong, Victoria, occurs what appears to be a hybrid between *C. glabra* and *C. lawrenciana*, both species are found in this area.

Both the holotype at Cambridge (CGE), and the isotype at Melbourne (MEL), of *C. glabra* bear the date 21st April 1836. According to Mitchell's Journal it was collected on the 22nd. There is a similar anomaly in the collecting dates of the type of *C. leucoclada*. The holotype at Cambridge is dated 29th April, the isotype at Melbourne 27th April, that given in the Journal being 16th April. Since the collecting was not done by Mitchell himself but by John Robertson it is not unlikely that when the plant names and descriptions were eventually inserted in the manuscript of Mitchell's Journal mistakes arose over the date of collection.

Distribution: South-east Queensland, central and eastern New South Wales, central and western Victoria, Mt. Lofty Ranges of South Australia.

QUEENSLAND. Mingoola ("Mongula"), *C. Stuart* (MEL).

NEW SOUTH WALES. Mingara, *J. Boorman* (NSW); Nandawar Range, *anon.* (NSW); Barraba, *A. Cooper* (NSW); Warrumbungle Ranges, *W. Forsyth* (NSW); Mt. Talbareeya, Mullaley, *Johnson and Constable* (NSW); Nymagee, *R. Cambage* 214(NSW); Timor Rock, *H. McKee* (NSW); Page R., Murrurundi, *J. H. Maiden* (AD); Stanthorpe, *F. M. Bailey* (NSW); Dripstone, Wellington, *G. Althofer* (NSW); Molong, *H. McKee* (NSW); Goolgowi, *E. Constable* (NSW); Mt. Wheoga, Grenfell, *E. Constable* (NSW); Tabletop, *E. McBarron* (NSW).

VICTORIA. Bendigo, *anon.* 11(MEL); Campbellfield to Darebin Ck., *P. St. John* (AD, MEL); Darling Desert, *F. Mueller* (MEL); Lower Goulburn R., *H. Pye* 36(MEL); Greensborough, *P. St. John* (MEL); Kororoit Ck., *P. St. John* (MEL); Lake Hindmarsh, *C. Walters* (MEL); Little Desert, *A. Swaby* (MEL); Melton, *E. Reader* 4(MEL); Mitiamo, *C. S.*

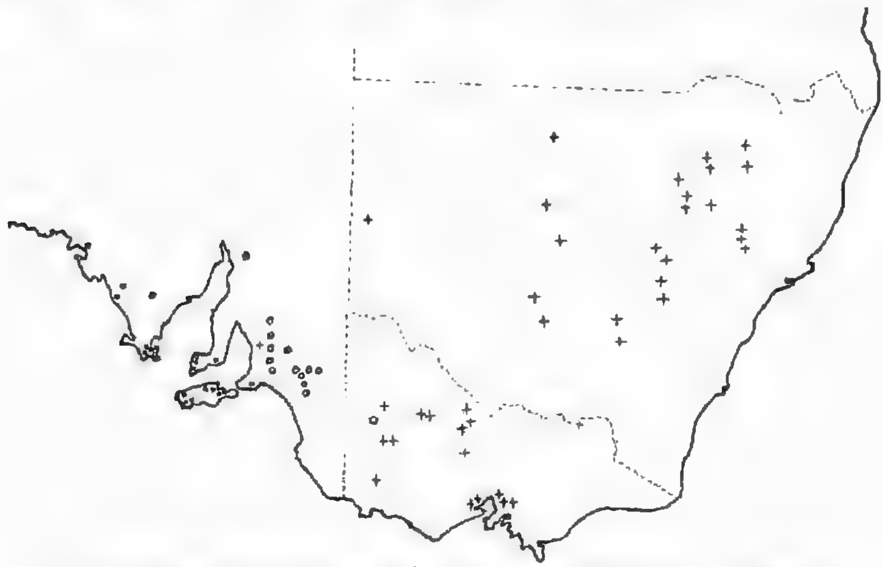

Fig. 4. Distribution of *Correa glabra* +; *C. pulchella* ●; *C. schlechtendalii* ○.

Sutton 92(MEL); Mt. Arapiles, *C. Beauglehole* (ACB); Mt. Dumaresq, *J. Gwyther* (BRI); Mt. Hope, *F. Mueller* (MEL); Saltwater R., Melbourne, *A. Lucas* (NSW); Somerton, *P. St. John* (MEL); Station Peak, You Yangs, *P. St. John* (MEL); Terricks, *A. Purdie* 392(MEL); Toolern Vale, *A. Tadgell* (MEL); Wando Vale, *Robertson* (NSW).

SOUTH AUSTRALIA. Mt. Lofty Ranges: Blackwood, *J. M. Black* (AD); Millbrook, *E. H. Ising* (AD); Morialta, *H. Salasoo* 1693(NSW); 4th Creek (Morialta), 1847, *C. Stuart* (MEL); Sturt Gorge, *E. L. Ashby* (ADW); Torrens Gorge, *R. Specht* (AD).

C. GLABRA × LAWRENCIANA ?

VICTORIA. Barwon Falls, nr. Geelong, 7 Apr. 1883, *W. B. Wilson* (MEL).

4. **Correa decumbens** *FvM.*, Trans.Vict.Inst. 1:30(1855); F. Muell., Pl.Vict. 1:137(1860-62); Benth., Fl.Austral. 1:356(1863); Black, Fl.S.Austral., 340 (1924); ed. 2. 497(1948); Ashby, Proc.Linn.Soc.Lond. Sess. 151:220(1939). Type, "Ad ripas Fl.Onkaparinga", 21 Dec. 1848, F. Mueller (lecto MEL).—Fig. 5A.

Procumbent woody plant to low shrub. Stem ferruginous tomentose when young. Leaves with petiole to 3·5 mm. long; lamina narrowly elliptic to oblong, to 4·5 cm. long and to 0·8(-1·0) cm. wide, glabrous and smooth above, light brown closely tomentose below, margin slightly recurved, apex rounded, base rounded to cuneate. Flowers erect, terminal on short axillary branches bearing

1-2 pairs of foliage leaves. Peduncle and bracts not differentiated. Pedicel 4-9 mm. long, ferruginous tomentose. Bracteoles linear to sub-foliaceous 0·5 cm. to 1 cm. long, inserted at base of pedicel, sometimes caducous. Calyx shallowly to deeply cupuliform with 4 sepaline and 4 intermediate lobes, 2-4 mm. high to base of lobes, ferruginous tomentose, sepaline lobes linear 3-5 mm. long, intermediate lobes triangular to lanceolate 0·5-2 mm. long. Corolla cylindrical, 1·8-2·7 cm. long, closely squamulose, tube pink to red, lobes erect green, corolla caducous after anthesis. Stamens with antipetalous filaments slightly broader at the base; anthers long exsert to about ½ to ⅔ the length of the

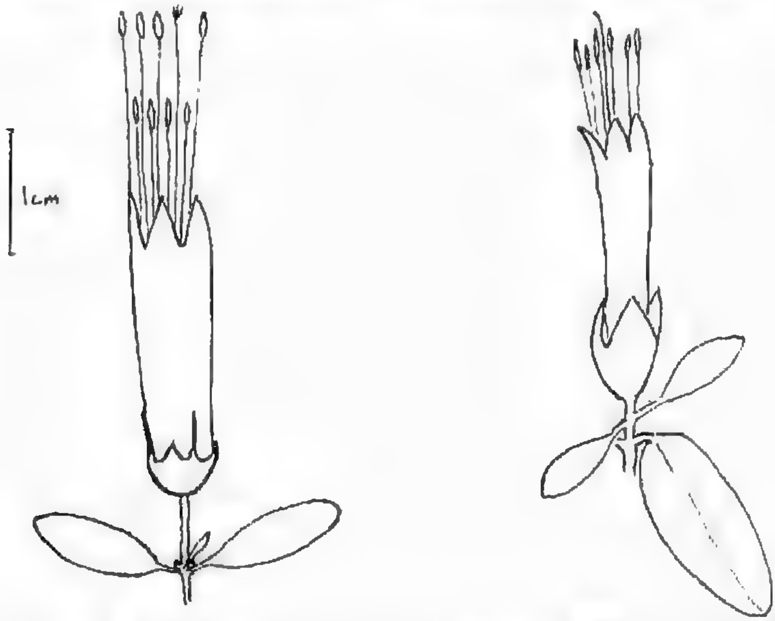

Fig. 5. A, *Correa decumbens* (Onkaparinga R., Eichler 14573); B, *C. calycina* (Hindmarsh Falls, R. Hill, 25 May 1958).

corolla, narrowly oblong to lanceolate, 2·2-3 mm. long, the margins not recurved after dehiscence. Ovary long rufous tomentose, style glabrous prominently 4-lobed at apex. Fruit with cocci to 7 mm. long, rounded at apex.

This species is well characterised by the long linear calyx lobes and the prominent intermediate lobes, and by its semiprocumbent habit. On Kangaroo Island all intermediates between *C. decumbens* and the local forms of *C. reflexa* occur. In the Grampians of Victoria are found plants with some characters intermediate between *C. reflexa* and *C. decumbens*. These plants have broadly ovate to narrowly oblong leaves, scabridulose above, and calyces with short dentoid sepaline lobes and strongly marked deltoid intermediate lobes, in other characters, e.g. size and shape of staminal filaments and anthers, pubescence of style, inflorescence, possession of well-marked peduncle and bracts, etc., they agree with *C. reflexa*. The marked variability of the plants from that area suggest that some form of hybrid swarm is involved but so far nothing closely approaching the typical *C. decumbens* has been recorded from Victoria.

Distribution: Southern Mt. Lofty Ranges and Kangaroo Island, S.A.

South Australia. Mt. Lofty Range: *F. Mueller* (syntype MEL); Aldgate, *E. H. Ising* (AD); Ambleside, *E. H. Ising* (AD, ADW); Bridgewater, *E. H. Ising* (AD); Clarendon, *Hj. Eichler* 14573(AD); Dashwood Gully, *J. B. Cleland* (AD); Deep Ck., *R. Schodde* 617(AD); Kangarilla, *E. H. Ising* (AD); Mt. Lofty, *H. B. Williamson* 2339(MEL); Mylor,

E. H. Ising (AD, ADW); Onkaparinga R., *Blandowsky* 50(MEL); ibid., 21 Dec. 1848 and Mar. 1851, *F. Mueller* (syntypes MEL); ibid., 1847, *C. Stuart* (syntype MEL); Stirling East, *E. H. Ising* (AD); Kangaroo Island: Breakneck R., *J. B. Cleland* (AD); Kelly Hill, *J. B. Cleland* (AD); Kinch's Station, Cygnet R., *J. G. O. Tepper* (MEL); Ravine de Casoars, *H. Cooper* (AD); Stunsail Boom R., *C. M. Eardley* (ADW).

C. DECUMBENS × REFLEXA

SOUTH AUSTRALIA. Kangaroo Island: Cassini, *H. W. Andrew* (AD); Kelly Hill, *J. B. Cleland* (AD); Sandy R., Flinders Chase, *P. Wilson* 938(AD); Vivonne Bay, *J. B. Cleland* (AD).

5. **Correa calycina** Black, Trans.Roy.Soc.S.Austral. 49:273(1925); Black, Fl. S.Austral. 692(1929); l.c. ed.2. 496(1948); Ashby, Proc.Linn.Soc.Lond.Sess. 151:217(1939). Type, Upper Waterfall, Hindmarsh Valley, South Australia, 29 Jan. 1924, J. B. Cleland (holo AD, iso K).—Fig. 5B.

Shrub erect to 8 ft. high. Young branches ferruginous flocculose. Leaves with petiole to 8 mm. long; lamina narrowly ovate or elliptic to oblong, entire, 2-4 cm. long, 0·8-1·4 cm. wide, glabrous above, thinly tomentose below, apex and base rounded to obtuse. Flowers solitary terminating lateral branches of irregular length with two or more pairs of leaves; the bracts and bracteoles not differentiated, i.e. the terminal pair of appendages are foliaceous. Pedicel 2-3 mm. long, densely tomentose, not thickened above. Calyx deeply cupuliform, tetragonal in cross-section, half to two-thirds divided into broadly lanceolate lobes, thinly tomentose outside and within, in all to 15 mm. long. Corolla cylindrical to 2·8 cm. long including the erect lobes, green, deciduous in fruit. Stamens with the antipetalous filaments slightly broader at the base, antisepalous more or less uniform in width. Anthers well exserted, sublanceolate 2·2-3·2 mm. long (dry), triangular in cross-section the margins not recurved (or only slightly so) after dehiscence. Style glabrous. Ovary white tomentose. Fruit ca. 7 mm. long, the cocci rounded at apex; the calyx lobes close over the ovary after anthesis.

This species is distinct, apart from the shape of the calyx, in being the only one in which the calyx is pubescent within. Material which appears to be a hybrid with *C. glabra* has been collected at the mouth of Myponga Creek near to where *C. calycina* occurs. Another curious form of *Correa* which J. M. Black referred to, *C. reflexa* (Fl.S.Austral. ed. 2. 496(1948)), occurs near the southern coast of Fleurieu Peninsula in the Encounter Bay region. It has thin ovate leaves, which are white pubescent beneath, and a distinctly 4-lobed white pubescent calyx. This plant grades into *C. calycina* and like that species has some pubescence within the calyx, it is extremely variable and for the moment I am treating it as a probable hybrid swarm of uncertain origin (see under *C. reflexa*).

Distribution. Known only from a few valleys at the southern end of Fleurieu Peninsula, S.Australia.

SOUTH AUSTRALIA. Mt. Lofty Range: Inman Valley, *E. Ashby* (AD, MEL); Hindmarsh Tiers, *J. B. Cleland* (AD); ibid., *H. Eichler* 13898(AD); ibid., "bush 8 ft. tall", *R. Schodde* 883(AD); Myponga, *J. B. Cleland* (AD).

6 **Correa backhousiana** *Hook.*, Journ.Bot. 1:253(1834); Backhouse in Ross, Hobart Town Alm. 80(1835); Hook., Comp.Bot.Mag. 1:276(1836); Hook., Ic.Pl. t.2(1837), Walpers, Rep.Bot.Syst. 1:506(1842); Hook.f., Fl.Tasm. 1:61(1855); Curtis, Students Fl.Tasm. 106(1956); Turrill, Bot.Mag. 171:289 (1957). Type, Cape Grim, Tasmania, 1833, J. Backhouse (holo K).

C. speciosa [race] b. *backhousiana* (Hook.) Benth., Fl.Austral. 1:355(1863) excl. syn.

C. speciosa var. *backhousiana* (Hook.) Rodway, Fl.Tasm. 21(1903).—Figs. 6A, 9.

Bush to 15 feet high. Branches ferruginous tomentose when young. Leaves with petiole 4-7 mm. long; lamina ovate to elliptic, normally broadly so, entire, to 3 cm. long and 2 cm. wide, coriaceous, dark green in colour, glabrous and smooth above, closely ferruginous tomentose beneath, apex obtuse to rounded, base cuneate to rounded. Flowers solitary or in clusters of 3 or more, normally terminal on lateral branchlets bearing 2-3 (or more) pairs of foliage leaves. Peduncle and bracts not differentiated. Pedicel 3·5-5 mm. long, densely ferruginous tomentose; bracteoles linear, ca. 3 mm. long, inserted at or near the base of the pedicel, caducous. Calyx cupuliform 4-5 mm. high, closely ferruginous tomentose outside, margin truncate and minutely 4-denticulate or undulate and then often slightly recurved, remaining wide open after anthesis. Corolla broadly cylindrical to slightly infundibuliform, 2·3-3 cm. long, cream to pale green in colour, caducous in fruit. Staminal filaments linear, the antipetalous broadened at the base. Anthers narrowly oblong, 3·2-4 mm. long (dry), included to barely exserted. Style glabrous or stellate pubescent towards the base. Ovary tomentose. Fruit 6-8 mm. high, cocci rounded at apex and slightly apiculate, not causing the calyx to split.

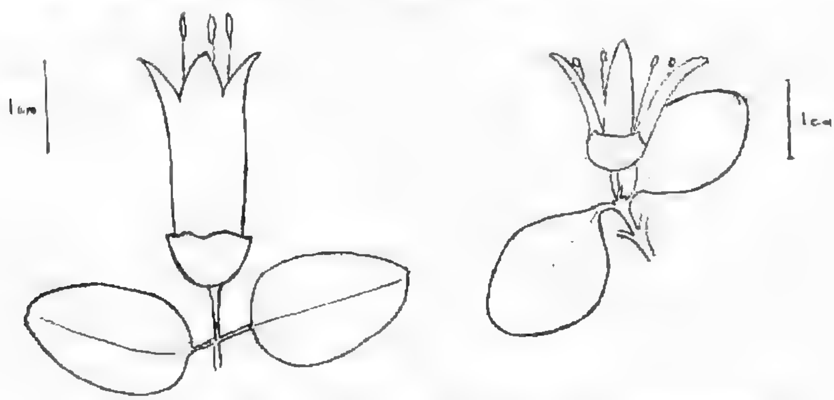

Fig. 6. A, *Correa backhousiana* (Pt. Davey, M. Davis 1294); B, *C. alba* (Palm Beach, NSW 44448).

C. backhousiana may be distinguished by its dark green broadly ovate coriaceous leaves, its long pedicel, green corolla, and calyx which remains open after anthesis (in *C. reflexa* it becomes closed).

This species has evident relationships with *C. reflexa* into which it merges through the forms of *C. reflexa* var. *coriacea* which I am distinguishing by its shorter corolla and usually red and green flowers. I have not seen any specimens which show any definite indication of hybridization with *C. reflexa* or *C. lawrenciana*.

Distribution: south, west, and north-west coasts of Tasmania; King Island (Tasmania).

Bass Strait. King Is.: *C. French* (MEL, NSW); *R. Perry* (CANB); *R. Brown* (MEL).

Tasmania. Woolnorth, *R. Gunn* (NSW); Circular Hd., *R. Gunn* (NSW); Rocky Cape, *R. Gunn* 456(NSW); Howth, *anon.* (HO); New Harbour, *C. Davis* (NSW); Pt. Davey, *F. Long* (HO); Bond Bay, *M. Davis* 1294(HO, MEL); Strahan, *Hj. Eichler* 16663(AD); Remine, *W. V. Fitzgerald* (NSW); Pieman R., *H. Comber* 2119(HO); Island on south coast, *Dr. Woolls* (NSW); Tasmania, *Labillardière* (MEL).

7. **Correa alba** *Andr.*, Bot.Rep. 1:t.18(1 Apr. 1798); Willd., Sp.Pl. 2:324(1799); Vent., Jard.Malm. 1:t.13(1803); Desfont., Ann.Mus.Par. 2:32(1803); Persoon, Syn.Pl. 1:419(1805); Smith in Rees, Cyclop. 10:(1807); Poir.,

Tabl.Encycl. 2(6):t.945 f.1(1819); ibid., 3(1):606(1823); Aiton f., Hort. Kew ed. 2. 2:349(1811); Edwards, Bot.Reg. 6:t.515(1821); DC., Prod. 1:719(1824); Jussieu, Mem.Mus.Paris 12:478 t.21 f.22(1825); Spreng., Syst.Veg. 2:215(1825); G. Don, Gen.Hist.Dich.Pl. 1:790(1831); Dietrich, Syn.Pl. 1269(1840); F. Muell., Pl.Vict. 1:135(1860-62); Benth., Fl.Austral. 1:354(1863); F. Muell., Native Pl.Vict. 1:66(1879); Moore, Fl.N.S.Wales 47(1893); Banks and Solander, Illust.Austral.Pl. 1:13 t.32(1905); Dixon, Pl.N.S.Wales 47(1906); Black, Fl.S.Austral. 340(1924); l.c. ed.2. 495(1948); Ewart, Fl.Vict. 694(1931); Ashby, Proc.Linn.Soc.Lond.Sess. 151:216(1939); Curtis, Students Fl.Tasm. 105(1956). Type, "it was first raised in the year 1793, from seeds which were given by Sir Joseph Banks, Bart., to J. Vere, Esq., of Kensington-gore, and from a plant in whose collection our figure was taken", Bot.Rep. t.18.

C. cotinifolia Salisb., Parad.Lond. t.100(1806) nom. illeg. Based in part on *C. alba*.

Mazeutoxeron rufum Labill., Voy.Rech.La Perouse 2:12(1800), Atlas t.17 (1800). Type, nr. Recherche Bay, south coast of Tasmania, Jan. 1793, Labillardière.

Fig. 7. Distribution of *Correa alba* var. *alba* ●; var. *pannosa* ○.

Correa rufa (Labill.) Vent., Jard.Malm. sub t.13(1803); Persoon, Syn.Pl. 1:419(1805); K. F. Gaertner, Fruct.Sem.Pl. 3:t.210, 155(1807); Labill., Nov. Holl.Pl. 2:120(1806-07); DC., Prod. 1:719(1824); Spreng., Syst.Veg. 2:215 (1825); G. Don, Gen.Hist.Dich.Pl. 1:790(1831); Spach, Hist.Nat.Veg.Phan. 2:336(1834); Dietrich, Syn.Pl. 1269(1840); Colla, Mem.Acad. Turin II. 5:492 (1843); Hook.f., Fl.Tasm. 1:61(1855).

C. alba var. *rotundifolia* DC., Prod. 1:719(1824); G. Don, l.c. (1831). Based on *C. rufa* (Labill.) Vent.—Figs. 6B, 7.

Prostrate to erect shrub to 5 ft. high. Young branches closely ferruginous tomentose to flocculose. Leaves with petiole 2-8 mm. long; lamina ovate to round or obovate, 0·8-3·5(-5) cm. long, 0·6-2·7(-3·5) cm. broad, entire, glabrous to pubescent above, thinly tomentose to pannose below. Flowers solitary or clustered at the end of short axillary branches. Peduncle not normally differentiated, bracts usually foliaceous. Pedicel 0·5-5 mm. long, tomentose; bracteoles linear to oblanceolate, 1-5 mm. long, inserted at or near the base of the pedicel, caducous. Calyx shortly cupuliform or semiorbicular, 2-4 mm. high, cream to ferruginous tomentose, truncate and 4-denticulate to deeply

sinuate between deltoid lobes, after anthesis becoming constricted between the carpels. Corolla 11-13 mm. long, the petals soon becoming ± free and spreading outwards, white (or rarely pale pink), deciduous in fruit. Staminal filaments distinctly broadened at the base; anthers enclosed, 1-2 mm. long, broadly oblong, margins not recurved after dehiscence. Ovary hirsute; style glabrous. Fruit with cocci to 7 mm. long, more or less truncate, normally splitting the calyx.

Key to Varieties

Leaves closely tomentose below. Pedicels 2·5-5 mm. long .... var. *alba*
Leaves thickly tomentose to pannose below. Pedicels 0·5-1·5 mm. long ...... var. *pannosa*

var. alba.

Erect shrub to 5 feet high. Leaves ovate to round or obovate, 1·5-3·5 cm. long, 1-2 7 cm. broad, sparsely pubescent and at length glabrous above, thinly to thickly tomentose beneath, apex rounded, base rounded to cuneate. Pedicel 2·5-5 mm. long; bracteoles linear to oblanceolate 1·5-5 mm. long. Anthers broadly oblong or obovate, ca. 2 mm. long.

This plant is practically confined to coastal beaches and cliffs. In New South Wales it has fairly large closely tomentose leaves and calyx with merely denticulate lobes. In Victoria, towards the west, the lobes become more prominent and the leaves smaller and more densely tomentose, thus grading into the typical form of var. *pannosa* at the Glenelg River. In Tasmania similar variations occur. Along the north coast of the island the leaves are only thinly tomentose below as in the eastern mainland forms, while in the south they are thickly ferruginous tomentose, a character which caused Labillardière to name the plant *M. rufum*. The calyx lobes of Tasmanian forms are deltoid.

Hybrids between *C. alba* and *C. reflexa* occur but do not appear to be common. The type of *C. rubra* is such a hybrid; it has the small enclosed anthers of *C. alba* while the leaves and corolla are intermediate between *C. alba* and *C. speciosa*, all three species of which were described from plants coming from the Botany Bay area.

Bentham l.c. and J. M. Black l.c. both record *C. alba* var. *alba* for South Australia including Kangaroo Island, but the material so determined by them that I have seen has been non-flowering specimens of forms of *C. reflexa*.

Andrews in Bot.Rep. l.c. states that the seeds giving rise to the plant figured were obtained from Sir Joseph Banks. It seems unlikely that they could have come from Banks' own collection made at Botany Bay in 1770. Possibly they were obtained from Capt. Phillip who was Governor of New South Wales from 1788 to 1793, and who corresponded with Banks; he returned to England early in 1793. The type locality even so is still probably in the Botany Bay area.

Distribution: From Newcastle south along the coast of New South Wales and Victoria as far west as Otway Peninsula; coastal regions of Tasmania.

New South Wales. Newcastle, *anon.* (NSW); Swansea, *W. Nicholls* (NSW); Kincumber, *J. Maiden* (NSW); Hawkesbury R., Barrenjoey, *J. Vickery* (NSW); Palm Beach, *E. Constable* (NSW); Port Jackson, *R. Helms* (NSW); Maroubra, *O. Evans* (CANB); Little Bay, *J. B. Cleland* (AD); La Perouse, *M. Mills* (NSW); Botany Bay, 1770, *Banks and Solander* (MEL, NSW); Kurnell, *J. Boorman* (NSW); Wollongong, *L. Johnson* 398(NSW); Port Kembla, Five Islands, *M. F. Day* (CANB); Gerringong, *anon.* (NE); Jervis Bay, *J. Maiden* (AD, NSW); Mt. Dromedary, *E. Reader* 31(MEL); Bermagui, *W. Baeuerlen* (NSW).

Victoria. Gabo Is., *Maplestone* (MEL); Cape Everard to Cape Howe, *anon.* 133 (MEL); Mallacoota, *N. Wakefield* 2483(NAW); Lindenow, Mitchell R., "limestone cliffs, many miles from the coast", *N. Wakefield* 3544(NAW); Wilsons Promontory, *F. Mueller* (MEL); Cape Paterson, *P. St. John* (MEL); Cape Schanck, *A. Howitt* (MEL); Sorrento, *F. Campbell* 3(BRI); Port Phillip, *R. Brown* (BRI, MEL); Frankston, *J. Staer* (NSW); Queenscliff, *St. E. D'Alton* 3(MEL); Pt. Lonsdale, *K. Cowle* (MEL); Geelong, *J. Paskoe*

(MEL); Barwon Falls, *W. Wilson* 24(MEL); Anglesea, *M. Davis* 133(AD); Anglesea to Aircy's Inlet, *D. Whibley* 161(AD); Cape Otway, *H. Williamson* (MEL).

TASMANIA. Flinders Is., *anon.* 260(MEL); Clarke's Is., *Marlaine* (MEL); Circular Hd., *R. Gunn* 428(NSW); Wynard, May 1924, *A. Lucas* (NSW); Burnie, *R. A. Black* (MEL); Ulverstone, *R. Black* (MEL); Devonport, *Hj. Eichler* 16995(AD); Georgetown, *C. Stuart* 577(MEL); Bridport, *W. Curtis* (HO); Diana Basin, *A. Simpson* (BRI); Dunalley, *Hj. Eichler* 16861(AD); Eaglehawk Neck, *J. Garden* (NSW); Pt. Arthur, *J. Batton* 7(MEL); Roaring Beach, Tasman Pen., *R. Carolin* 1807(AD); Bruny Is., *R. Black* (MEL).

C. ALBA × REFLEXA

VICTORIA. Cape Everard, *Walter* (MEL); Wilsons Promontory, 12 May 1853, *F. Mueller* (MEL).

var. **pannosa** nom.nov.

C. rotundifolia Lindl. in Mitchell, Three Exped. E.Austral. 2:217(1838); Lindl., Ann.Sci.Nat. II. 15:58(1841); Walpers, Rep.Bot.Syst. 2:824(1843). Type, near the mouth of the Glenelg R., south-west Victoria, 15 Aug. 1836, T. L. Mitchell 287 (holo CGE, iso MEL).

C. alba var. *rotundifolia* (Lindl.) Benth., Fl.Austral. 1:354(1863) non DC. (1824); Ewart, Fl.Vict. 694(1931); Black, Fl.S.Austral. 495(1948); nom.illeg.

Small procumbent to erect shrub. Leaves broadly elliptic or rotund, 0·7-1·7 cm. long, 0·6-1·4 cm. wide, tomentose above or eventually glabrous or somewhat scabridulous, densely pannose below. Flowers solitary or densely clustered; pedicels 0·5-1·5 mm. long. Anthers 1-1·5 mm. long (dry), usually becoming lunate after dehiscence.

The plants I have seen growing at Encounter Bay, S.A., were procumbent, those growing in south-west Victoria have been described as being erect. Specimens from the two regions also differ in the nature of the calyx lobes, at Encounter Bay the calyx is practically truncate, whereas in south-west Victoria the calyx has prominent deltoid lobes. However, the leaf shape and indumentum and other floral and inflorescence characters of the two forms correspond closely.

Distribution. Along the south-west coast of Victoria and the Encounter Bay region of South Australia.

VICTORIA. Bridgewater, *C. Beauglehole* 5096(ACB); Portland, *C. Beauglehole* 394 (ACB); Glenelg R., *C. Walter* (NSW); Nelson, *C. Beauglehole* 695(ACB).

SOUTH AUSTRALIA. Lake Alexandrina, Nov.-Dec. 1847, *C. Stuart* (MEL); Pelican Pt., Coorong, *anon.* (AD); Encounter Bay, *J. B. Cleland* (AD); Waitpinga Cliffs, *R. Hill* (AD).

8. **Correa pulchella** *Mackay* ex *R. Sweet*, Fl.Austral t.1(1827); Sweet, Hort. Brit. 89(1827) nomen.; Lindl., Bot.Reg. 15:t.1224(1829); G. Don, Gen.Hist. Dich.Pl. 1:790(1831); Dietrich, Syn.Pl. 1269(1840); Walpers, Rep.Bot. Syst. 1:505(1842); Bot.Mag. t.4029(1843). Type, figure drawn from plant raised by J. Mackay, Clapton nursery, from seeds collected by William Baxter at Kangaroo Island, South Australia (holo K ?).

C. rubra var. *pulchella* (Sw.) Black, Fl.S.Austral. ed.2, 496(1948).

C. reflexa var. *pulchella* (Sw.) Court, Vict.Nat. 73:175(1957).

C. neglecta Ashby, Proc.Linn.Soc.Lond. Sess. 151:217 et 219(1939). Type, Cape Spencer, Yorke Peninsula, South Australia, E. Ashby (holo AD).

C. neglecta var. *minor* Ashby, l.c. 219, without a Latin diagnosis, nom.illeg.

C. minor (Ashby) Black, Fl.S.Austral. ed.2, 496(1948), comb.illeg.

[*C. speciosa* [race] d. *glabra* auct.non (Lindl.) Benth.: Benth., Fl.Austral. 1:355(1863) p.p.]

[*C. rubra* var. *glabra* auct.non (Lindl.) Black: Black, Fl.S.Austral. 340(1924) p.p.]—Figs. 4, 8A.

Small erect shrub to ca. 2 feet high (rarely more). Leaves with petiole to 3·5 mm. long; lamina oblong, narrowly or broadly elliptic to broadly ovate,

10-20 mm. long, 1·5-15 mm. wide, thin to coriaceous, upper and lower surfaces glabrous or subglabrous, light green in colour, apex obtuse, base cuneate to rounded. Flowers solitary, horizontal to pendulous, terminal on short axillary branchlets bearing 1-3 pairs of foliage leaves, the terminal pair often smaller and caducous, no typical peduncle or bracts differentiated. Pedicel ± glabrous, 4-10 mm. long, thickened below the calyx; bracteoles minute, caducous, ca. 0·5 mm. long, inserted at the base of the pedicel. Calyx broadly cupuliform or semiorbicular, ca. 4 mm. long, margin entire, ± truncate, green, glabrous or very slightly pubescent, remaining wide open after anthesis. Corolla entirely pinkish red, broadly cylindrical or infundibuliform, closely squamulose, 1·7-2·7 cm. long, lobes erect or spreading, deciduous in fruit. Staminal filaments distinctly broadened at the base; anthers enclosed or just exserted, broadly oblong, 1-1·5 mm. long, the margins not recurved after dehiscence. Ovary practically glabrous to tomentose; style glabrous or sparsely pubescent at the base; disc white to purple. Fruit ca. 4 mm. high shortly exceeding the calyx, cocci rounded above not causing the calyx to split.

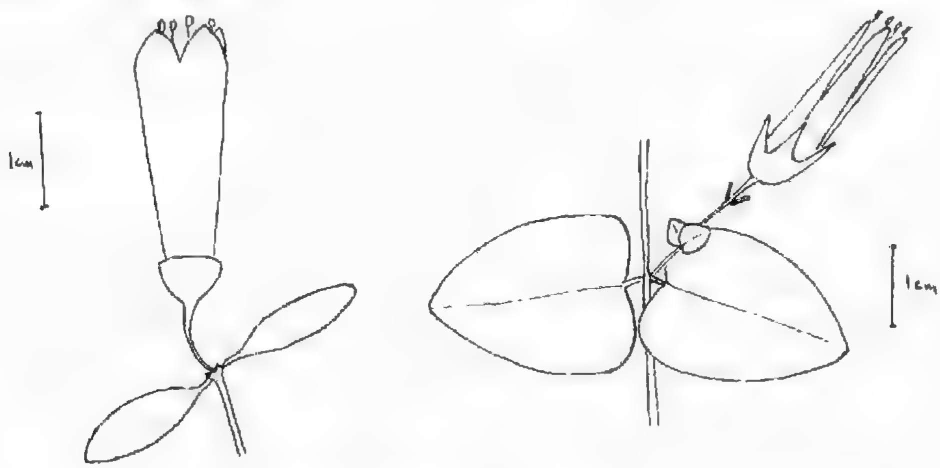

Fig. 8. A, *Correa pulchella* (Kangaroo Is., P. Wilson 737); B, *C. aemula* (Hindmarsh Tiers, R. Schodde 1028).

This species is quite distinct from all the other species of *Correa* including *C. reflexa*. It is distinguished by its light green practically glabrous leaves, long swollen pedicel, and entirely pinkish corolla. It has smaller anthers than any other species except *C. alba*. One peculiarity with which it shares with *C. backhousiana* is the calyx which remains wide open after anthesis.

The leaf shape varies greatly even on the same bush and the corolla size and shape within a small area is also inconstant. There are differences between plants coming from their present three main areas of distribution, i.e. Kangaroo Island, and Yorke and Eyre Peninsulas, but not sufficient to warrant subspecific status.

Hybrids between *C. pulchella* and *C. reflexa* var. *nummulariifolia* have been found at Remarkable Rocks (south-western Kangaroo Island), and with *C. reflexa* var. *reflexa* at Encounter Bay and possibly at Cape Banks, south-east of South Australia. All the hybrids have larger anthers (over 2 mm.), a more pubescent pedicel and calyx, and a deeper red corolla. The shape of the corolla and leaf also show intermediate characters.

Distribution: Eyre Peninsula, Yorke Peninsula, and Encounter Bay, South Australia.

South Australia. Kangaroo Island: American R., *E. H. Ising* (AD); Bay of Shoals, *J. Tepper* 56(MEL); Cape Borda, *P. Wilson* 689(AD); Cape du Couedic, *P. Wilson* 630(AD); Kelly Hill, *P. Wilson* 925(AD); Kingscote, *Mrs. R. Rogers* (NSW); Ravine de Casoars, *R. S. Rogers* (NSW); Remarkable Rocks, *J. B. Cleland* (AD); Rocky R., *J. B. Cleland* (AD); Stokes Bay to Middle R., *R. Rogers* (NSW).

Fleurieu Peninsula, Waitpinga Ck., *R. Filson* 848(AD).

Yorke Peninsula: Corny Pt., *Hj. Eichler* 14079(AD); Cape Yorke, *S. White* (AD); Pondalowie Bay, *S. White* (AD); Stenhouse Bay, *D. N. Kraehenbuehl* 165(AD); Warrow, *Dr. Schmid* 3(MEL).

Eyre Peninsula: Coffin Bay, *Wilhelmi* (MEL); Cape Wiles, *E. M. Newman* (AD); Elliston, ca. 30 km. south of, "edge of salt pan", "5ft. high", *T. Lothian* (AD); Memory Cove and Port Lincoln [Bay IX and X], 1802, *R. Brown* (MEL); Memory Cove, *P. Wilson* 344(AD); Mt. Drummond, Pt. Lincoln, *C. Wilhelmi* (MEL); Polda, *J. B. Cleland* (AD). Streaky Bay, *Mrs. Richards* (AD); Venus Bay, *J. H. Willis* (MEL).

C. PULCHELLA × REFLEXA

South Australia. Kangaroo Island, Remarkable Rocks, *J. B. Cleland* (AD); Fleurieu Peninsula, Encounter Bay, 16 Jan., 30 Aug., 16 Nov. 1924, 16 May 1927, *J. B. Cleland* (AD).

9. **Correa aemula** (Lindl.) FvM., Fragm. 1:3(1858); F. Muell., First General Report, 10(1853) without reference to basionym; F. Muell., Pl.Vict. 1:139 t.7(1860-62); Benth., Fl.Austral. 1:353(1863); C. Muell., Walpers' Ann.Bot. Syst. 7:524(1868); F. Muell., Native Pl.Vict. 1:65(1879); F. Muell., Key Syst.Vict.Pl. 2:f.14(1885); Black, Fl.S.Austral. 340(1924); l.c. ed.2. 495 (1948); Ewart, Fl.Vict. 694(1931); Ashby, Proc.Linn.Soc.Lond. Sess. 151:215(1939).

Didimeria aemula Lindl. in Mitchell, Three Exped. E.Austral. 2:197(1838); Lindl., Ann.Sci.Nat. II. 15:59(1841); Walpers, Rep.Bot.Syst. 5:390(1845-46). Type, between Douglas (at White Lake) and the Glenelg R. at Mostyn, south-west Victoria, 28 July 1836, T. L. Mitchell 266 (iso MEL).

Correa affinis Ashby, Proc.Linn.Soc.Lond. Sess. 151:215(1939). Type, Lower Mt. Lofty Ranges, E. Ashby (holo AD).

Correa speciosa var. × *hillii* Guilfoyle, Austral.Pl. 118(1910) pro sp.; *anon.*, Vict.Nat. 23:131 and 133(1906) nomen. = *C. aemula* × *reflexa*. Type, Mt. Cole nr. Beaufort, Grampians, Oct. 1906 [G. R. Hill] (holo MEL).—Figs. 8B, 9.

Small bush 2-3 feet high, semi-procumbent to erect. Stem ferruginous tomentose. Leaves with petiole to 4 mm. long, lamina ovate to subcordate, to 3 (-4) cm. long and 2·5 cm. wide, entire, chartaceous, sparsely stellate pubescent above and below, apex obtuse, base truncate to slightly cordate. Flowers solitary (rarely in pairs), axillary. Peduncle 0·5-1 cm. long; bracts (persistent) subsessile, cordate to orbicular 2-7 mm. long. Pedicel glabrous to sparsely pubescent, thickened above, 1·2-2·6 cm. long; bracteoles (persistent) linear to filamentous 0·5-2 mm. long, inserted ca. two-thirds from base of pedicel. Calyx broadly cupuliform, deeply 4-lobed, 2-4 mm. long to base of lobes, green, glabrous to loosely ferruginous pubescent, chartaceous; lobes lanceolate, ± acuminate 3-8 mm. long. Corolla cylindrical, soon becoming split into 4 narrowly oblong petals which infold around their contiguous stamens, 2-3 cm. long, green to pale purple, the colour deepening with age. Staminal filaments linear, the antipetalous broaden slightly at their base; anthers oblong, narrowing towards their apex, ca. 2·5 mm. long, the margins not recurved after dehiscence, slightly exsert or just enclosed within the corolla. Ovary tomentose, style glabrous. Fruit ca. 8 mm. high, apex of cocci rounded, not splitting the calyx, the corolla persistent in fruit.

This species is easily recognized by the deeply lobed calyx, split corolla, and the long peduncle and pedicel bearing the characteristic bracts and bracteoles. Hybrids between it and *C. reflexa* have been found in the Grampians at Hall's Gap, Ararat, and Beaufort.

C. speciosa var. *hillii* is a hybrid between *C. aemula* and *C. reflexa*, collections so named and presumably those on which Guilfoyle's name was based show gradations between the two species.

The distinction made by Edwin Ashby (that of pubescence) between the Victorian and South Australian forms is one of degree only and all intermediates may be found, his further distinguishing character of absence of bracteoles in *C. aemula* was presumably due to poor material, the Victorian material I have seen possesses bracteoles

Fig. 9. Distribution of *Correa aemula* ●; *C. backhousiana* ○; *C. baeuerlenii* +.

In the Vict.Nat. 17:59(Aug. 1900) *C. aemula* is recorded as being collected by Mr. Ed. E. Pescott on Mt. Buck, nr. Orbost, Victoria. The corresponding specimen in the Melbourne Herbarium shows the record to consist of two pieces of *C. reflexa* stuck on to a piece of *C. aemula*. The origin of the *C. aemula* portion is therefore in doubt.

Distribution: Mt. Lofty Range and Kangaroo Is., South Australia; The Grampians, Victoria.

SOUTH AUSTRALIA. Mt. Lofty Range: Inman Valley, *E. Ashby* (ADW); Hindmarsh Falls, *R. Schodde* 1028(AD); Boundey R., *E. Jackson* 294(AD); Myponga, *J. M. Black* (AD); Encounter Bay, Oct. 1847, *F. Mueller* (MEL); Tanunda, *F. Mueller* (MEL). Kangaroo Island: Breakneck R., *J. B. Cleland* (AD); Rocky R., *J. B. Cleland* (AD); Kelly Hill, *J. B. Cleland* (AD).

VICTORIA. Grampians: *D. Symon* 147(AD, ADW); Hall's Gap, *J. Audas* (BRI); Mt. Rosea, *J. Audas* (BRI); Mt. Victory, *E. Jackson* 311(AD); McKenzie Falls, *R. Robbins* (ACB); Horsy Ck., *C. Walter* (NSW); Dunkeld, *J. Staer* (NSW); Stawell, *W. E. Mathews* 34(MEL); Mt. Abrupt, *C. French* (MEL); Mt. Sturgeon, *H. Williamson* (MEL); Mt. Zero, *H. B. Williamson* (MEL); Victoria Range, *Finck and Beauglehole* (ACB).

C. AEMULA × REFLEXA

VICTORIA. Grampians: *Gauba* (CAUBA); Ararat, *Hill* 1,4(NSW); nr. Ararat, "Field Nat.Show Oct. 1906", ex herb. *C. Walter* (MEL, isotype *C. speciosa* var *hillii* ?); Hall's Gap, *Burford* (AD).

10. **Correa lawrenciana** *Hook.*, Journ.Bot. 1:254(1834); Hook.f., Fl.Tasm. 1:61 (1855); F. Muell., Pl.Vict. 1:138(1860-62); Benth., Fl.Austral. 1:355(1863); Walpers, Rep.Bot.Syst. 1:506(1842); Moore, Fl.N.S.Wales 47(1893); Rodway, Fl.Tasm. 21(1903); Ewart, Fl.Vict. 695(1931); Curtis, Students Fl.Tasm. 106(1956). Syntypes, Tasmania, Lawrence s.n. (K), R. Gunn s.n. (K).

C. lawrenciana var. *glabra* Benth., l.c. (1863) non (Lindl.) Hook.f. (1855); Rodway, Fl.Tasm. 21(1903); Curtis, Students Fl.Tasm. 107(1956); nom.illeg. Type, Derwent R., Tasmania, R. Brown 5323 (holo K).

C. ferruginea Backhouse in Ross, Hobart Town Alm. and Van Diem. Land Ann. 80(1835); Hook., Ic.Pl. 1:t.3(1837). Type, "It is abundant in the middle region of Mount Wellington".

C. ferruginea Gunn ex Hook., Comp.Bot.Mag. 1:276(1836); Maund, Botanist 3:t.124(1839); Hook., Journ.Bot. 2:417(1840); Walpers, Rep.Bot.Syst. 1:506 (1842). Type, Hobart Town, Tasmania, Gunn 557 (= 457 ?) (holo K). Nom. illeg.

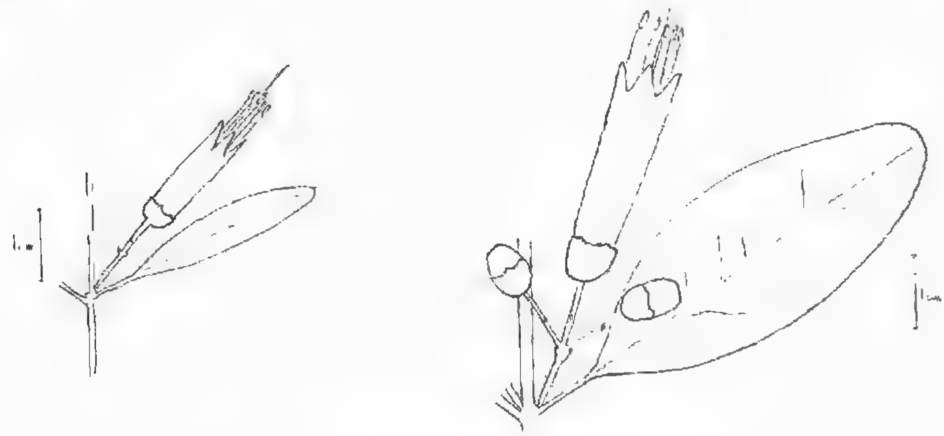

Fig. 10. *Correa lawrenciana* var. *lawrenciana*: *A*, *Tasmania* (G. Weindorfer T.1810); B, Otway Peninsula (D. Whibley 187).

C. lawrenciana var. *ferruginea* Hook.f., Fl.Tasm. 1:62(1855), based on *C. ferruginea* Gunn ex Hook.

C. latrobeana FvM. ex Hannaford, Jottings in Australia 40(1856); Dietrich, Fl.Univ. II. t.11(1861) without text; F. Muell., First General Report 10(1853) nomen. Type, Delatite River, 20 Mar. 1853, F. Mueller (lectotype MEL, iso NSW ?).

[*C. lawrenciana* var. *glabra* auct.non. (Lindl.) Hook.f.: Hook.f., Fl.Tasm. 1:62(1855).]

Shrub or small tree 2 to 30 feet high. Branches ferruginous, finely tomentose to pannose or flocculose. Leaves distinctly petiolate; lamina narrowly to broadly elliptic or ovate, 2·4 cm. long and 0·7 cm. wide to 8 cm. long and 6 cm. wide, upper surface glabrous, smooth, lower surface glabrous to finely or densely tomentose, pannose, or flocculose, chartaceous to coriaceous, apex acute to rounded, base cuneate to subcordate. Inflorescence an axillary (rarely ter-

minal) cyme of 1-3(-7) flowers. Peduncle erect or recurved 0·4 cm. to 5 cm. long; terminal bracts, which are normally caducous in the bud, filamentous to oblanceolate, 0·2 cm. to 0·5 cm. long (or sometimes subfoliate and up to 3 cm. long in var. *macrocalyx*). Pedicels tomentose, 0·5 cm. to 1·0 cm. long; bracteoles caducous in the bud, filamentous, 0·5 mm. to 2 mm. long, inserted from base to apex of pedicel. Calyx shallowly to deeply cupuliform, 4 to 6 mm. wide, 3 to 8 mm. (-10 mm.) high, subglabrous to densely ferruginous tomentose or pannose, lobes dentoid to broadly obtuse or rarely acuminate (lanceolate and up to 3 mm. long in var. *genoensis*). Corolla more or less cylindrical, 1·6-3·2 cm. long, 0·4-0·7 cm. broad, squamose to velutinous, greenish yellow to red; lobes erect. Staminal filaments not or scarcely broader at the base; anthers lanceolate, 2·5-3 mm. long, well exserted to about half the length of the corolla, the margins recurved after dehiscence so as to partially obscure the back of the anther. Style glabrous. Ovary densely tomentose and somewhat hirsute. Fruit up to 9 mm. long, the cocci spreading at maturity causing the calyx to split. The torn corolla and staminal filaments persist even after the fruit has dehisced.

Key to Varieties

1. Calyx without apparent glandular dots, ± pubescent (rarely sub-glabrous).
    2. Flowers greenish yellow or red, leaves broadly elliptic to broadly ovate, chartaceous to coriaceous.
        3. Leaves chartaceous to coriaceous ± elliptic, base cuneate to obtuse; peduncle to 1·5 cm. long; calyx 3-5 mm. high; flowers green (or rarely red) ...... var. *lawrenciana*
        3. Leaves chartaceous, broadly ovate, base obtuse to subcordate; peduncle 1-5 cm. long; calyx 4-10 mm. high.
            4. Bracteoles (caducous) inserted at base of pedicel, corolla red (or rarely greenish yellow) .... var. *cordifolia*
            4. Bracteoles (caducous) inserted at or near apex of pedicel subtending the calyx; calyx (5-)7-10 mm. high, sparsely pubescent; corolla greenish yellow. var. *macrocalyx*
    2. Flowers red; leaves oblong-elliptic, coriaceous .... var. *rosea*
1. Calyx with prominent glandular dots, subglabrous or glabrous.
    5. Calyx lobes merely dentoid. (Queensland-N.S.Wales border.) var. *glandulifera*
    5. Calyx lobes lanceolate, acuminate, from half as long to as long as the calyx tube. (S.E. Victoria.) .... var. *genoensis*

var. lawrenciana—Figs. 10, 13A.

Leaves narrowly to broadly elliptic. 2·4 cm. × 0·7 cm. to 6·5 cm. × 3·4 cm., glabrous to densely tomentose or pannose below, chartaceous to coriaceous, apex rounded to obtuse, base obtuse to cuneate. Peduncles 0·4 cm. to 1·5 cm. long, erect or somewhat recurved; terminal bracts caducous when flowers are in bud. Flowers 1-3(-7) in a cyme; pedicels 3-10 mm. long; bracteoles filamentose, caducous, inserted usually near the middle of the pedicel. Calyx shallowly to deeply cupuliform, 3-5 mm. high, ferruginously squamate to tomentose. Corolla yellowish green (rarely red), 1·6-2·5 cm. long. Fruit to 7 mm. high, the cocci rounded at their summit.

Correa lawrenciana was first described from specimens collected by R. W. Lawrence and Ronald Gunn in Tasmania. The description given by W. J. Hooker fits those plants found in the northern part of the island around Launceston. *C. lawrenciana* var. *glabra* was described by Bentham from a plant collected by R. Brown on the Derwent. In both the leaves are relatively small (ca. 3 cm. long), thin, and glabrous below. The peduncle is short, up to 0·5 cm. long, and bears only one flower. The corolla is also small being up to 2 cm. long. W. J. Hooker (1834) states that the plant reaches a height of 8-10 feet. Towards the southern and western parts of the island the leaves become larger (up to 8 cm. long, 2·5 cm. wide), thicker, and densely ferruginous below, and the flowers longer (up to 2·5 cm. long). This corresponds to the descrip-

tion of *C. ferruginea* Backh., described by Backhouse as coming from Mt. Wellington, Hobart, and Macquarie Harbour. On Mt. Wellington also occurs a form with smaller and thicker leaves. All the Tasmanian forms grade into each other, only the extremes of which would comfortably fit into the separate specific or varietal categories which have been made.

On the mainland of Australia var. *lawrenciana* is similarly complex. In the Grampians occurs a small bushy form (similar to that found on Mt. Wellington) with small thick leaves densely lanose beneath, a short one-flowered peduncle, a deeply cupuliform ferruginous calyx and a short velutinous corolla. In the high mountains to the south of the Snowy Mts. is found a similar form with small thick leaves and short red or green corollas. Around Mts. Buffalo and Latrobe and the Delatite River occurs a large leaved form with flowers in threes or fives on peduncles of about 1 cm., a coarsely tomentose calyx and velutinous corolla. This is F. Mueller's *C. latrobeana*, a name which he himself does not appear to have used apart from in one or two early lists of plants and on some herbarium specimens. In eastern Victoria near Buchan is a form with large elliptic leaves, flowers in threes, the calyx with prominent acuminate lobes ca. 4 mm. long, and a red corolla. All intermediates between these and other less prominent forms are found, and again it appears unwise to retain or create subspecific divisions for them.

A specimen which appears to be a hybrid between *C. glabra* and *C. lawrenciana* has been collected at Barwon Falls near Geelong. It shows characters intermediate between the forms of the two parent species growing there.

As will be noted in the synonymy, the name *C. latrobeana* was first published by F. Mueller in 1853 as a nomen. In 1856 Samuel Hannaford in "A Catalogue of the Plants Common in the Colony of Victoria" (the second part of his "Jottings in Australia") gives a very brief description of the species and under habitat, "Delatite". I have therefore chosen a Mueller specimen collected in 1853 on the R. Delatite as the Lectotype, a portion of which, according to Mueller's pencil note, was sent to Dietrich, and it is therefore probably a duplicate of the material from which the latter made his plate which was published in 1861.

Distribution: Tasmania, Victoria and south-east New South Wales.

AUSTRALIAN CAPITAL TERRITORY. Brindabella Range, *Gauba* (GAUBA).

NEW SOUTH WALES. South-east region, Baw Baw, nr. Goulburn, *C. French* (NSW). Delegate, *W. Baeuerlen* 183(MEL); Snowy Mts., Jacobs R., *Althofer* 945(COOMA); Thredbo R., *C. Ingram* (INGRAM).

VICTORIA. Grampians: Mt. Rosea, *D. Symon* 270(AD, ADW); Mt. William, *D. Sullivan* (MEL); Cape Otway Ranges, *J. Mulder* 7(MEL); You Yangs, *J. Mulder* (MEL); Wild Dog Ck., Apollo Bay to Beech Forest, *D. Whibley* 187(AD); Powelltown, *C. White* (BRI); Bennak, *F. Campbell* (BRI); Warburton, *Pitcher* (MEL); Berwick, *Robinson* (MEL); Yarra Ranges, *F. Mueller* (MEL); sources of Bunyip R., *F. Mueller* (MEL); Healesville, *P. St. John* (MEL); Blacks Spur, nr. Healesville, "small slender tree", *anon.* 1401(NSW); Grace Burn R., C.W. (NSW); Mt. Erica, 4000 ft., *C. French* (MEL); Bright, *J. Maiden* (NSW); Howqua R., *T. Whaite* (NSW); Mitta Mitta, *A. Meebold*, 21598(NSW); Tanjil Bren, *J. Galbraith* (ACB); Acheron, "*tree* 30 ft.", *L. Fraser* (NSW, SYD); Matlock, *J. Staer* (NSW), Mt. Baw Baw, *H. Tisdall* 19(MEL); Mt. Fainter, *Mrs. McCann* (MEL); Buffalo Range, *F. Mueller* (MEL); Mt. Latrobe, 4-5000 ft., *F. Mueller* (MEL); Erskine R., *L. G. Dale* (ACB); Mt. Seldomseen, 4000 ft., *N. A. Wakefield* 2272(NAW); Upper Buchan R., 1000 ft., *N. Wakefield* 4841(NAW); Mt. Buck, *N. Wakefield* 3548(NAW); Mt. Ellery, *E. Merrah* (MEL); sources of Delegate R., *E. Merrah* (MEL); Bemm R. headwaters, *E. Merrah* 3(MEL), Don R., *C. Sutton* (MEL); Newmerella, *Grove* 4(MEL); Bonang, *W. Forsyth* (NSW); Wattle Tree, Buchan, *L. Hodge* (MEL).

BASS STRAIT. King Is., *E. Smith* (HO).

TASMANIA. Penguin, *R. Gunn* 153(NSW); Harford, *H. Hamilton* 135(CANB, HO); Mersey R., *anon.* 334 and 335(MEL); Port Dalrymple, *R. Brown* (BRI); Deloraine, *R. Black* (MEL); Westbury, *Simson* (MEL); Launceston, *S. Hannaford* 107(MEL, NSW); Mt. Barrow, "shrub 3 ft.", *N. Burbidge* 3001(CANB, HO); Snug Plains, Hobart, *Hj. Eichler*

16835(AD); Derwent R., *J. Lutrell* (AD); Mt. Wellington, *F. Rodway* 1215(NSW); ibid. [Feb. 1804], *R. Brown* (MEL); Dromedary, New Norfolk, *R. Black* (MEL); Southport, *anon.* 1815(MEL); Recherche Bay, *J. Maiden* (NSW); Gordon R., *J. Milligan* 728(MEL).

var. **cordifolia** var.nov.—Figs. 11A, 13B.

Folia late ovata vel subcordata, ad 7·5 cm. longa, 5 cm. lata, chartacea, infra laxe flocculosa. Pedunculus filiformis 1·5-5 cm. longus; pedicellus 0·5-1·5 cm. longus bractiolis base insertis. Calyx cupuliformis, ferrugino-tomentosus, minute 4-dentatus, ad 0·5 cm. altus, 0·6 cm. latus. Corolla pallido-rubra (rare virido-flava) ad 2·7 cm. longa. Holotypus, Mt. Dromedary, Central Tilba, 800 ft., 12 Sept. 1953, "erect spreading bush 5-7 ft.", E. F. Constable, NSW 26186 (AD).

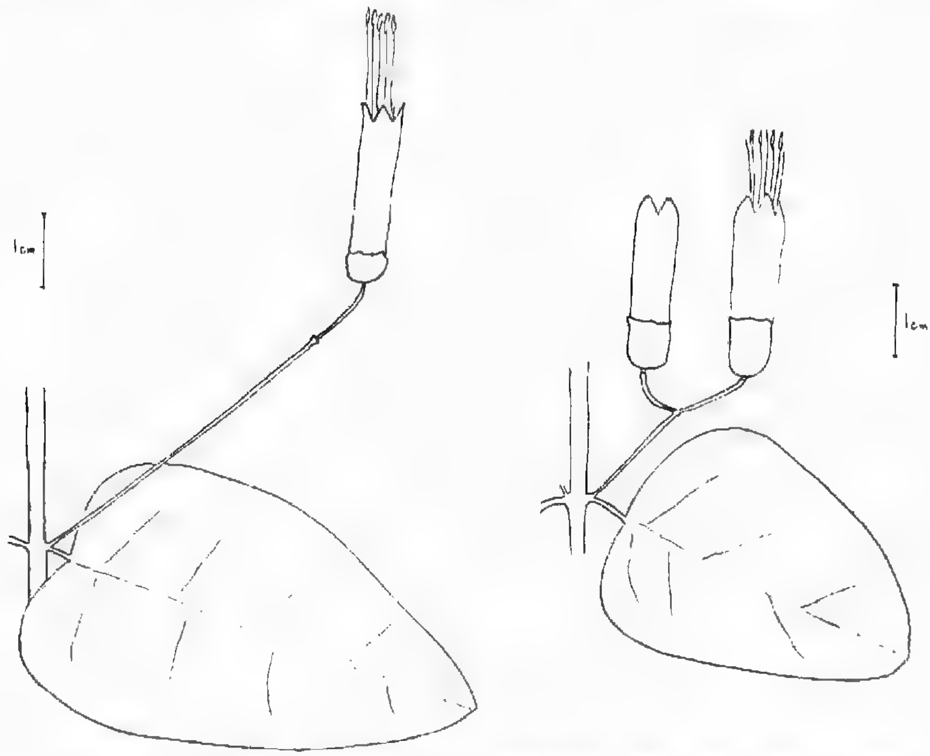

Fig. 11. A, *Correa lawrenciana* var. *cordifolia* (Mt. Dromedary, NSW 26186, holotype); B, var. *macrocalyx* (Patonga Ck., NSW 16271).

Leaves broadly ovate with the base rounded to subcordate, chartaceous, loosely flocculose beneath. Flowers 1-3 at the end of slender peduncles 1·5-5 cm. long. Pedicels 0·5-1·5 cm. long with the minute caducous bracteoles inserted at the base. Calyx cupular, ferruginous tomentose, minutely 4-dentate. Corolla squamulose pubescent, pale red with the apex brownish tinged (or rarely entirely greenish yellow), to 2·7 cm. long.

This plant grows apparently to a height of about 8 feet, and occurs in localities not far from the coast. It does not appear to extend as far north as does var. *macrocalyx* and I have not seen any specimens intermediate between the two varieties. It is characterised by its leaf shape, long peduncles, and basal bracteoles.

Distribution: South-eastern New South Wales.

NEW SOUTH WALES, south coast. Bermagui, *W. Dunn* 122(NSW); Bodalla, "spreading bush 6 ft. high", *A. Floyd* 1(NSW); Cobargo, "3-8 ft.", *J. Boorman* (NSW); Clyde R. district, *W. Baeuerlen* 417(MEL); Conjola Ck., Milton, *Hadley* (NSW); Little Forest, Milton, *F. Rodway* 1219(NSW); Lawlers Ck., Bodalla State Forest, "5-7 ft.", *E. Constable* (AD); Milton, *R. Cambage* 4149(NSW); Mt. Dromedary, Central Tilba, *Bice* (NSW); Table Mt., Milton, *R. Cambage* 4026(NSW); Tilba, *E. Reader* 37(MEL); Turpentine Ck., Milton, *R. Cambage* 4140(NSW).

var. **macrocalyx** (*Blakely*) stat. nov.

C. macrocalyx Blakely, Proc.Linn.Soc.N.S.Wales 54:681(1929). Type, Patonga, Hawkesbury R., N.S.Wales, Oct. 1923, Shiress and Blakely (not seen).—Figs. 11B, 13E.

Leaves broadly ovate, chartaceous, loosely flocculose below, base rounded to subcordate, apex obtuse. Peduncle 1·5-4·5 cm. long; bracts oblanceolate and ca. 10 mm. long to foliaceous, usually caducous. Pedicel 0·5-1·2 cm. long, the bracteoles minute and subtending calyx. Calyx deeply cupuliform, sparsely stellate pubescent, (5-)7-10 mm. long, margin sinuate. Corolla greenish yellow, velutinous, to 2·3 cm. long.

Specimens of this variety from the type locality at Patonga have very long calyces, those collected further south have them only to 5·5 mm. long.

According to W. F. Blakely it is a loosely branched shrub 3-12 feet high, usually producing several stems from a woody rootstock. It is notable for its deep subglabrous calyx and for the bracteoles being inserted almost directly underneath the calyx.

Distribution: Only known from the type locality on the Hawkesbury River and further south at Minnamurra, New South Wales.

NEW SOUTH WALES. Hawkesbury R., Patonga Ck., 10 Sept. 1926, *W. Blakely* (MEL, NSW); ibid., 6 Dec. 1925 and 28 Aug. 1927, *W. Blakely* (NSW); Minnamurra, 2 May 1954, *J. Judd* 30(NSW); Middle Brother State Forest, 16 Apr. 1960, *E. Winterhalder* (NE).

var. **rosea** var.nov.—Fig. 13G.

Folia anguste elliptica, plana, sub-coriacea, infra dense tomentosa, apici obtuso, basi cuneata vel obtusa, ad 6 cm. longa, 1·3 cm. lata. Corolla pallido-rubra. Holotypus, Geehi River, Alpine Way, 10 Apr. 1958, J. Vickery, NSW 51508(NSW).

Leaves narrowly elliptic, subcoriaceous, densely tomentose beneath, to 6 cm. long, 1·3 cm. wide, apex obtuse, base cuneate to obtuse. Flowers usually solitary; peduncle 3-7 mm. long, pedicel 5-8(-15) mm. long. Calyx closely ferruginous squamose, 3-5 mm. high, ca. 6 mm. wide. Corolla pale red.

This variety appears to have been first noticed by F. Mueller during his visit to the Hume River district of Mt. Kosciusko in January 1874. He refers to it in Fragm. 8:142 (March 1874) as "*C. lawrenciana* (var. floribus amoene rubris)", and again l.c. 9:117 (August 1875), a mention of it was also made in his Report of the Government Botanist p. 8 (1874). It apparently grows along the alpine watercourses up to an altitude of 4,500 feet and reaches a height of 6-12 feet.

Intermediates between var. *rosea* and the red-flowered form of var. *lawrenciana* found near Buchan occur. To the south-east of Mt. Kosciusko at Mt. Tingiringi there is a form with much smaller and thicker broadly elliptic leaves and with small rufous flowers which appears to have relationships with var. *rosea* and the Grampian form of var. *lawrenciana*.

Distribution: Snowy Mts., New South Wales.

NEW SOUTH WALES. Snowy Mts.: Cobberas Mts., 5000 ft., *W. Hunter* (MEL); Crackenback R., *C. Ingram* (INGRAM); Happy Jack R., 3800 ft., *I. Filmer* (NSW); Hume R., ca. 4000 ft., "on the banks of brooks", "12-20 ft. high", *F. Mueller* (MEL); Island Bend,

Althofer 944(COOMA); Jindabyne, *W. Baeuerlen* (NSW, BRI). Lobbs Hole, *W. Forsyth* (NSW); Mt. Kosciusko, *F. Mueller* (MEL); ibid., 5000 ft., *J. McLuckie* (CANB); Mt. Tingiringi, 5000 ft., "4-6 ft.", *W. Baeuerlen* 176(MEL); Upper Murray R., *Findlay* (MEL); Pipers Ck., Snowy R., 4500 ft., "6 ft.", *L. Johnson* (NSW); Tooma R., *F. Cambell* (BRI); Upper Tumut R., *Whitfield* (NSW).

var. **glandulifera** var.nov.—Figs. 12A, 13D.

Folia ovata vel elliptica, chartacea, subtus minute tomentosa, integra. Calyx brevite cupuliformis vel tanden patelliformis ad 2 mm. altus, 4 mm. latus, subglaber, glanduloso-punctatus, margine undulato, 4-dentato. Fructus carpelli prominenter apiculatis. Holotypus: Queensland: Springbrook, 3,000 ft., 21 Sept. 1929, "large shrub or small tree in dense Eucalyptus forest, very common also as secondary growth", C. T. White 6274(BRI).

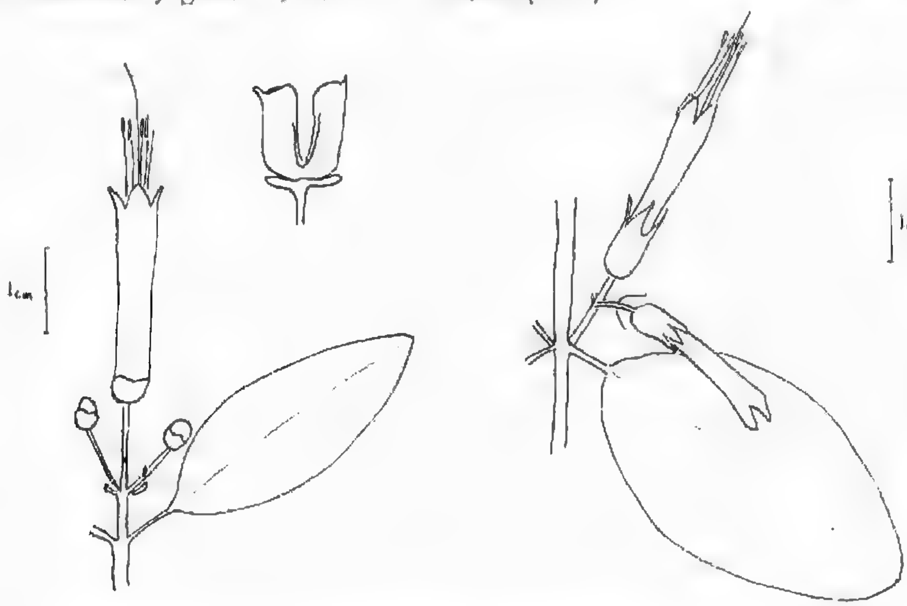

Fig. 12. A, *Correa lawrenciana* var. *glandulifera*, with fruit (C. T. White 6274, holotype); B, var. *genoensis* (Genoa R., F. Mueller).

Shrub to 20 feet high. Young branches closely ferruginous tomentose. Leaves with a petiole to 1 cm. long; lamina ovate, entire, chartaceous, minutely tomentose beneath, to 8 cm. long, 3·5 cm. wide, apex acute, base cuneate. Peduncle 2-7 mm. long bearing 1-5 flowers, terminal bracts linear-oblong, ca. 4 mm. long. Pedicel 4-10 mm. long, bracteoles (caducous) in the lower half or basal to 3 mm. long. Calyx shortly cupuliform becoming patelliform in fruit, 2 mm. high, ca. 4 mm. wide, sparsely pubescent or subglabrous, prominently glandular punctate, margin undulate, minutely 4-dentate. Corolla to 2·7 cm. long, 0·4 cm. wide, squamose tomentose, greenish-yellow. Carpels to 9 mm. high in fruit, prominently apiculate and with a longitudinal ridge along their outer margins.

This variety is readily distinguished by the thin minutely tomentose leaves and by the short, almost glabrous, calyx which has prominent glandular dots. The apiculate fruit is also characteristic.

I have seen specimens only from the Macpherson Range, probably all from near Springbrook. Robert Brown, in his manuscript notes, recorded a glandular species of *Correa* from Newcastle, N.S.W. I have not seen a specimen of any

C. lawrenciana variety from this locality but it is possible that var. *glandulifera* does or did once extend southwards into New South Wales, although it is unlikely that it would be present as far south as Newcastle.

Distribution: Macpherson Range, south-east Queensland.

QUEENSLAND. Macpherson Range, Springbrook: "shrub about 15 ft.", *C. T. White* (BRI, NSW); 2000 ft., "small tree about 12 ft. high", *D. Goy and L. Smith* 226(BRI); 3000 ft., "shrub 6-8 ft.", *C. Hubbard* 491(BRI, K); 2600 ft., "shrubby, 15-20 ft.", *S. T. Blake* 15895(K).

var. **genoensis** var.nov.—Figs. 12B, 13C.

Folia late ovata vel elliptica, integra, ad 6 cm. longa 2·8 cm. lata, infra sparse vel dense lanosa. Flores axillaris; pedunculus brevis, 3-6 mm. longus, bractei anguste oblanceolatis ad 4 mm. longis; pedicellus ad 5 mm. longus, bracteolis linearibus, ad 5 mm. longis, prope base pedicelli inserti. Calyx chartaceus, urceolatus, sparsi pubescens vel glaber, lobis lanceolatis ad 3 mm. longis. Holotypus: East Victoria; Genoa River, "flooded banks", Sept. 1860, "calyx green", F. Mueller (MEL).

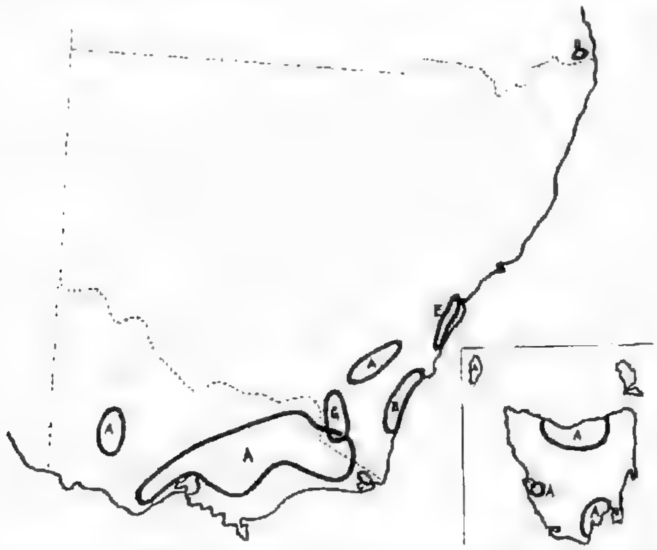

Fig. 13. A, Distribution of *Correa lawrenciana* var. *lawrenciana*; B, var. *cordifolia*; C, var. *genoensis*; D, var. *glandulifera*; E, var. *macrocalyx*; G, var. *rosea*.

A shrub with loosely tomentose branches. Leaves entire broadly ovate to elliptic, subcoriaceous, to 6 cm. long, 2·8 cm. wide, sparsely to densely lanose beneath, base obtuse to rounded, apex obtuse. Flowers axillary; peduncles only 3-6 mm. long, bracts (caducous) narrowly oblanceolate; pedicel to 5 mm. long, bracteoles (caducous) linear, to 5 mm. long, inserted at or near the base of the pedicel. Calyx urceolate, to 7 mm. long to base of lobes, glabrous or subglabrous with scattered glandular dots, lobes lanceolate ca. 3 mm. long. Corolla to 2·3 cm. long, colour pale red (?).

This interesting plant, described by one collector, E. Reader, as a low shrub, apparently grows along the banks of the Genoa River where it is subjected to periodic flooding, all the herbarium specimens (4 collections) show presence of detritus. The most characteristic feature is the thin urceolate calyx which is only sparsely pubescent even in the bud, and which has very long lanceolate lobes.

Distribution: Genoa River, far east Victoria.

VICTORIA. Genoa R.: 1860, *F. Mueller* (MEL isotype ?); River Banks, 23 May 1880, "low shrub", *E. Reader* 81(MEL).

11. **Correa baeuerlenii** *FvM.*, Proc.Linn.Soc.N.S.Wales 9:960(1885); Moore, Fl.N.S.Wales 47(1893) Oliver, Hook. Ic.Pl. 23:t.2245(1892). Type, The Clyde, Sept. 1884, W. Baeuerlen 1 (lectotype MEL, iso. BRI ?); near Bateman's Bay, on rivulets, Oct. 1884, W. Baeuerlen s.n. (syntype MEL).—Fig. 9.

A small shrub, branches closely ferruginous pubescent. Leaves ovate or almost lanceolate to elliptic, entire, 2·2 to 6·5 cm. long, 1 to 2·2 cm. wide, chartaceous, sparsely and minutely pubescent below when young, eventually glabrous, apex obtuse to acute, base obtuse to cuneate. Flowers terminal or axillary, solitary. Peduncle (when axillary) 3-12 mm. long, ferruginous tomentose; bracts (caducous) oblanceolate ca. 3 mm. long (or rarely subfoliate). Pedicel ferruginous tomentose 8-10 mm. long; bracteoles linear ca. 1·5 mm. long caducous in bud, affixed towards the base of the pedicel. Calyx broadly cylindrical, to 7 mm. high, ca. 6 mm. wide, chartaceous, sparsely pubescent or subglabrous, mouth irregularly undulate and ± 4-dentate, base produced into a patelliform process ca. 9-10(13) mm. diameter, at first horizontal, later with the margin reflexed. Corolla cylindrical 2-2·8 cm. long, glabrous towards the base otherwise squamellate pubescent, greenish yellow, lobes deltoid ca. 4 mm. long. Staminal filaments linear, very slightly broadened at the base. Anthers well exsert, lanceolate, ca. 2·3 mm. long (dry), their margins recurved after dehiscence. Ovary densely hirsute. Style glabrous. Fruit with the cocci rounded at the summit, to 9 mm. long, separating and spreading above causing the calyx to split. Corolla persistent in fruit.

C. baeuerlenii, the most curious species within the genus, is outstanding because of the patelliform appendage at the base of the calyx, not one of the other species shows any sign of such an outgrowth.

The relationship of this species is probably with *C. lawrenciana*. The narrow staminal filaments, well exserted anthers with reflexed margins, persistent corolla, and spreading cocci are characters also found in the latter, while the leaves in their shape, texture and indumentum are similar to the northern Tasmanian form of var. *lawrenciana*. It appears to inhabit damp gullies and banks of streams, and to be confined to the lowlands.

Distribution: Clyde River district, south-east New South Wales.

NEW SOUTH WALES. Braidwood District, 3500 ft., *W. Baeuerlen* (MEL); Nelligan, *W. Baeuerlen* (NSW); Bolaro Mtn., "only locality", *W. Baeuerlen* (BRI); Clyde R., *W. Baeuerlen* (MEL); Wapengo Ck., nr. Bega, "shrub 6 ft. tall, occurs in the damper gullies", *A. Floyd* 1(NSW).

UNCERTAIN SPECIES

Correa revoluta *Vent.*, Jard.Malm. sub t.13(1803); Persoon, Syn.Pl. 1:419 (1805). Nomen sub-nudum, origin unknown.

EXCLUDED SPECIES

"**Correa papyrifera** *Caill.* voy. a Meroe." D. Dietrich, Synops.Pl. 2:1269 (1840), presumably intended to be:—

Amyris papyrifera Delile, Cent. Pl. Afr. Voy. Méroé 99(1826); Delile in Cailliaud, Voyage à Méroé 4:389(1827), = *Boswellia papyrifera* (Delile) A. Rich., Tent.Fl.Abyss. 1:148(1847).

ACKNOWLEDGMENTS

I should like to express my thanks to the Curators of the University and State Herbaria who have kindly sent specimens on loan and also in particular to C. Beauglehole, R. Filson, C. Ingram, K. Rohrlach, M. Sharrad, N. Wakefield, and L. Williams who have lent their private collections and often made special efforts in the field to obtain further *Correa* material.

Index to Names

Italics indicate synonyms; numbers refer to species.

× pallida *Hort.*, Paxt.Mag.Bot. 12:77(1846), "C. alba × rufa".
papyrifera D. Dietrich ≡ Boswellia papyrifera (*Delile*)*A. Rich.* (Under "Excluded Species".)
× picta *Hort.*, Paxt.Mag.Bot. 12:77(1846), "C. speciosa × virens".
pulchella Hort., Bot.Reg. t.1224(1829) = pulchella *Mack.* ex *Sw.*
pulchella *Mack.* ex *Sw.* 8
reflexa (*Labill.*)*Vent.* 1
,, var. cardinalis (*FvM. ex Hook.*)*Court* 1
,, var. coriacea *P. G. Wils.* 1
,, var. *glabra* (Lindl.)Court 3
,, var. nummulariifolia (*Hook.f.*)*P. G. Wils* 1
,, var. *pulchella* (Sw.)Court 8
revoluta *Vent.*, nomen sub-nudum. (Under "Uncertain Species.")
roseo-alba *Hort.*, Paxt.Mag.Bot. 14:147(1848), no parents mentioned
rotundifolia Lindl. 7
× rubescens *Hort.*, Paxt.Mag.Bot. 12:77(1846), "C. lindleyana × speciosa".
rubicunda Soland. ex Britten 1
rubra Sm. 1
,, var. *glabra* (Lindl.)Black 3, (8), (2)
,, var. *megacalyx* Black 1
,, var. *orbicularis* Black 1
,, var. *pulchella* (Sw.)Black 8
,, var. *turnbullii* (Ashby)Black 2
,, var. *virens* [Sm.]Ewart 1
× *rubra* Hort., Paxt.Mag.Bot. 14:147(1848), no mention of parents
rufa (Labill.)Vent. 7
schlechtendalii *Behr* 2
speciosa Donn ex Andr. 1
,, "race" *backhousiana* (Hook.)Benth. 6, (1)
,, var. *backhousiana* (Hook.)Rodway 6
,, f. *cardinalis* (FvM. ex Hook.)Voss 1
,, "race" *glabra* (Lindl.)Benth. 3, (8), (2)
,, var. *glabra* (Lindl.)Maid. et Betche 3
,, var. *hillii* Guilfoyle 9
,, "race" *leucoclada* (Lindl.)Benth. 3
,, var. *leucoclada* (Lindl.)Maid. et Betche 3
,, "race" *normalis* Benth. 1
,, var. *nummulariifolia* Hook.f. 1
,, var. *virens* (Sm.)Hook.f. 1
turgida *Hort.*, Floricult.Cab. 8:112(1840), not seen
turnbullii Ashby 2
ventricosa *Hort.*, Thurston, Trees and Shrubs of Cornwall. 99(1930).
virens Hook. 1
virens Sm. 1
viridiflora Andr. 1
viridiflora-alba *Hort.*, Paxt.Mag.Bot. 14:147(1848), no parentage indicated
viridis Spach, Hist.Nat.Phan. 2:236(1834) = virens Sm.

Correaea Post et Ktze., Lexic.Gen.Phan. 143(1903 = Correa.
Correas Hoffmsg., Verzeichniss der Pflanzenkult. 1:168(1824) not seen = Correa
Didimeria Lindl. cf. sub Correa.
aemula Lindl. 9
Didymeria Lindl., Ann.Sci.Nat. II, 15:59(1841) = Didimeria.
Didymoria Meisn., Pl.Vasc.Gen.Comment. 347(1843) = Didimeria
Mazentoxeron Wittst., Etym.Bot.Handw. 563(1852) = Mazeutoxeron
Mazeutoxeron Labill. cf. sub Correa
reflexum Labill. 1
rufum Labill. 7

REVISION OF THE TATE MOLLUSCAN TYPES: PELECYPODA - NUCULIDAE AND NUCULANIDAE

BY N. H. LUDBROOK

Summary

The paper is the second of a series revising the Tertiary molluscan species described or identified by Ralph Tate. The Nuculidae are represented by three species of *Pronucula,* the Nuculanidae by eleven species belonging to five genera.

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[Read 11 May 1961]

SUMMARY

The paper is the second of a series revising the Tertiary molluscan species described or identified by Ralph Tate. The Nuculidae are represented by three species of *Pronucula*, the Nuculanidae by eleven species belonging to five genera.

INTRODUCTION

All the material redescribed in the present paper is in the Tate type collection belonging to the Geology Department of the University of Adelaide. Holotypes of a few species are located elsewhere, the following abbreviations being used for the collections in which they are housed:

A.U.G.D.: Adelaide University Geology Department.
M.U.G.D.: Melbourne University Geology Department.
A.M.: Australian Museum, Sydney.

I am indebted to the Director and Dr. D. F. McMichael of the Australian Museum, Sydney, for the loan of type material.

PHYLUM MOLLUSCA
Class PELECYPODA
Family NUCULIDAE
Genus PRONUCULA Hedley

Pronucula Hedley, 1902, Aust. Mus. Sydney Mem. 4, 290.

Type species (o.d.) *Pronucula decorosa* Hedley

Pronucula morundiana (Tate).

(pl. 1, figs. 1, 2)

Nucula morundiana Tate, 1886, p. 128, pl. 4, figs. 2a-2c.

Pronucula morundiana (Tate), Ludbrook, 1955, p. 20 (includes references to publication of name in lists).

Diagnosis. A high, tumid, trigonal *Pronucula* with inner margins of valves minutely denticulate; sculpture of equal rounded concentric ribs.

Description. Shell minute, tumid, solid, trigonal, nearly equilateral, posterior side roundly angulate; posterior dorsal margin straight; anterior side rounded. Surface sculptured with regular equal rounded concentric ribs, about 12 per mm., faintly crossed by microscopic radial striae.

Umbo high, tumid, subcentral and directed posteriorly, hinge line arcuate and broad with 5 strong posterior and 8 anterior teeth. Chondrophore broadly triangular. Valve margin thin dorsally, moderately thick and finely denticulate ventrally.

Dimensions. Length 2·8 mm., height 2·8 mm.

Holotype. A.U.G.D., Tate Coll. T.1042.

Type Locality. Muddy Creek, Hamilton, Victoria; ? Muddy Creek Marls.

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* Palaeontologist, Geological Survey of South Australia. Published with the permission of the Director of Mines.

Material. Holotype and 9 paratypes on small tablet, 7 specimens from Muddy Creek mounted in 2 rows – 3 in the top row of which the right-hand specimen is the holotype; 4 in the second row. The third row contains 2 valves from Mornington and the fourth row 2 valves from near Morgan (? Cadell Marl Lens).

Stratigraphical Range. Miocene. (?) Pliocene.

Pronucula tatei (Finlay).

(pl. 1, figs. 5, 6)

Nucula semistriata Tate, 1886, p. 128, pl. 4, figs. 5a-5b (*non* Wood).

Nucula tatei Finlay, 1924, p. 107; 1927, p. 491 (*nom. mut.*).

Diagnosis. A medium size nearly smooth *Pronucula.*

Description. Shell small, obliquely trigonal, only moderately inflated. Umbo situated at posterior one-quarter; posterior side short and flatly rounded, anterior side produced and rounded; dorsal margins very gently rounded, ventral margin broadly rounded. Umbones high and recurved. Surface sculptured with flat and slightly retroflexed growth folds, becoming more conspicuous ventrally, faintly crossed by microscopic radial striae. Hinge line only moderately broad, with 11 teeth anteriorly and 5 posteriorly. Chondrophore small, oblique. Margin finely and conspicuously denticulate.

Dimensions. Length 5·75 mm., height 4·5 mm., inflation (both valves) 3 mm.

Holotype. A.U.G.D., Tate Coll. T.1045.

Type Locality (here designated). Blanche Point, Aldinga Bay; Blanche Point Marls, Upper Eocene.

Material. Holotype and 9 paratypes on tablet labelled "Eocene, Adelaide; Aldinga". There is nothing on the tablet to indicate which specimens came from the "*Turritella* clays" (Blanche Point Marls) at Blanche Point and which from the glauconitic sands of Adelaide (i.e. Kent Town) Bore.

Stratigraphical Range. Blanche Point Marls, Upper Eocene.

Pronucula fenestralis (Tate).

(pl. 1, figs. 9, 10)

Nucula fenestralis Tate, 1886, p. 129, pl. 4, fig. 4.

Diagnosis. A minute *Pronucula* with strong coarse cancellate sculpture, the radial ribs becoming obsolete anteriorly and posteriorly.

Description. Shell minute, fragile, translucent, shining, ovate-oblong, somewhat tumid, posterior margin roundly arcuate, anterior side produced and angulate, straight towards the dorsal margin and rounded to the ventral margin. Umbo in the posterior third and directed posteriorly. Surface strongly and fairly coarsely cancellate except at the anterior and posterior where the radial ribs become obsolete and the shell has only concentric ribs. The radial ribs are not developed in the umbonal third which carries fine concentric threads.

Hinge line broad and rounded with five posterior teeth, anterior portion broken but there are probably 8 anterior teeth of which 4 are preserved. Chondrophore small, slightly oblique. Margin obsoletely denticulate in the posterior dorsal portion but smooth elsewhere.

Dimensions. Length 2·25 mm., height 1·875 mm.

Holotype. A.U.G.D., Tate Coll. T.1044.

Type Locality. Table Cape, Tasmania.

Material. The holotype and 2 paratypes, all more or less imperfect.

Observations. This very distinctive cancellate species is similarly sculptured to the Recent *P. decorosa* Hedley and *P. vincentiana* Cotton and Godfrey.

Stratigraphical Range. Oligocene of Table Cape only.

Family NUCULANIDAE

Genus Nuculana Link, 1807

Nuculana Link, 1807, Beschreib. Nat.-Samml. Rostock. Abt. 3, 155.

Type species (monotypy) "*Arca rostrata* Chemnitz" = *A. pernula* Müller

Subgenus Saccella, Woodring, 1925

Saccella Woodring, 1925, Carnegie Inst. Wash. Pub. 366, 15.

Type species (o.d.) "*Arca fragilis* Chemnitz" = *Lembulus deltoideus* Risso, 1826

Nuculana (Saccella) chapmani Finlay.

(pl. 2, figs. 1, 2)

Leda apiculata Tate, 1886, p. 131, pl. 9, figs. 4a, 4b. *non Nucula apiculata* Sowerby *nec Nucula apiculata* Reuss

Nuculana chapmani Finlay, 1924, p. 107 *nom. mut.* for *L. apiculata* Tate *non* Sowerby.

Nuculana chapmani Finlay, 1927, p. 523 *nom. nov.* for *L. apiculata* Tate *non* Reuss.

Diagnosis. An inflated rather broad *Saccella* sculptured with regular angular concentric upturned ribs sharply cut off on the dorsal side which become weaker and obsolete posteriorly.

Description. Shell of moderate size, ovate, broadly subtrigonal, inequilateral, inflated. Umbo situated a little to the anterior, inflated, rounded and recurved. Anterior inflated, margin rounded, posterior shortly and sharply rostrate, posterior-dorsal margin slightly concave and curved upward at the end. Ventral margin strongly arcuate. Lunule broad and well defined. Surface sculptured with fine regular concentric upturned ribs, about 10 per mm. dorsally and separated by linear grooves. The threads are strongest over the anterior and median portions of the shell and in older specimens become weaker and obsolete towards the rostration. The threads turn roundly on the rostrum and become weaker and finer on the lunule as they turn up towards the umbo.

About 15 chevron-shaped teeth in each series on either side of a very small deep chondrophore.

Dimensions. (Holotype.) Length 9·5 mm., height 5·5 mm., inflation (both valves) 4 mm.

Holotype. A.U.G.D., Tate Coll. T.1036A.

Material. Tate's original tablet marked "*Leda apiculata* Tate", with the holotype and 24 paratypes mounted in 4 rows. The top row contains 7 complete specimens of which the holotype is the middle one, all presumably from Aldinga. Row 2 contains 6 specimens, 4 of which marked "4" are from Snapper Point, Victoria; one marked "5" from Table Cape, and one "7" from Camperdown. The third row contains 9 specimens presumably from Adelaide (Kent Town) Bore, only the six on the left belonging to the species. Three small shells on the right do not belong to "*Leda apiculata* Tate" but to a small undescribed *Saccella* from Kent Town Bore. The fourth row has 6 specimens marked "3" from Gellibrand River; one at the right marked "6" from Spring Creek is probably not conspecific with the others and belongs to *Nuculana* (*Saccella*) *fontinalis* (Pritchard).

Type Locality. Blanche Point Marls, Blanche Point, Aldinga Bay, S.A. Upper Eocene.

Stratigraphical Range. Upper Eocene to Lower Miocene.

Nuculana (Saccella) vagans (Tate).

(pl. 2, figs. 5, 6)

Leda lucida T. Woods, 1880, p. 3, pl. 1, figs. 5, 5a. *non* Loven.

Leda lucida Tate, 1886, p. 131, pl. 6, figs. 7a, 7b. *non* Loven.

Leda vagans Tate, 1887, p. 188. *nom. mut.* for *Leda lucida* Tenison Woods, Tate, 1886.

Nuculana vagans Tate (sp.) Harris, 1897, p. 348.

Diagnosis. A fairly large robust subventricose *Saccella* with variable sculpture of concentric striae and growth lines generally smooth in the umbonal area.

Description. Shell solid, thick, subventricose, triangularly subovate, umbones subcentral, slightly directed posteriorly, anterior side rounded, posterior side shortly rostrate, dorsal margin roundly sloping anteriorly, slightly concave posteriorly. Ventral margin curved and tending to be somewhat straight in the middle, curving sharply up towards the posterior rostration. Surface with fine concentric striae and growth lines except for umbonal area which is generally smooth. Lunule well defined, broad, lenticular, striated. Hinge plate strong, gently angulate, separated by a narrow triangular ligament pit; 13 chevron-shaped teeth and about 4 immature teeth in the anterior series, 13 chevron-shaped and about 7 immature teeth in the posterior series.

Dimensions. Holotype of *Leda lucida* T. Woods length 5 mm., height 3 mm.; Hypotype figured by Tate 1886 length 18 mm., height 11 mm., inflation (both valves) 8 mm.

Holotype. A.M. F.1808; hypotype, figured Tate A.U.C.D. T.1034A; hypotype figured this paper pl. 2, figs. 5, 6, T.1034Q.

Type Locality. Muddy Creek, Hamilton, Victoria; Muddy Creek Marls.

Material. The holotype A.M. F.1808 of *Leda lucida* T. Woods. Two tablets in the Tate Collection: T.1034 with 29 specimens, 14 of which are from Morgan (Cadell Marl Lens), 6 from Muddy Creek, 4 from Snapper Point, 3 from Corio Bay, and 2 from Spring Creek. A complete growth series is represented on this tablet, 5 examples from Morgan and 3 from Snapper Point being longer than the rest. Muddy Creek topotypes are small. Tablet T.1038 with 9 examples in 2 rows, one specimen from Camperdown, 3 from Fyansford and 5 from Gellibrand River.

Stratigraphical Range. Miocene.

Observations. The holotype of *L. lucida* T. Woods is an immature left valve of the same size as the right hand (sixth) topotype of the fourth row of T.1034; specimen T.1034M from Morgan (an immature right valve) is very close to the holotype.

Nuculana (Saccella) fontinalis (Pritchard)

(pl. 2, figs. 3, 4)

Leda fontinalis Pritchard, 1901, p. 28, pl. 3, figs. 3, 3a.

Diagnosis. A small tumid subtrigonal *Saccella* with an acute-angled rostration, sharp keel and a flattened posterior area.

Description. Shell small, subtrigonal, inequilateral, umbones subcentral, situated a little to the anterior. Anterior side rather sharply rounded, posterior side shortly and sharply rostrate. Anterior dorsal margin slightly convex, posterior dorsal margin nearly straight and but slightly concave towards the rostrum; ventral margin very gently arcuate and tending to be straight in the middle. Surface sculptured with somewhat irregular concentric grooves which become deeper and stronger and more crowded towards the ventral margin. Posterior to the umbones a very broad flat triangular area bounded by a sharp keel.

Hinge plate strong, fairly broad, the anterior and posterior series making an angle of about 120 degrees and separated by a small deeply set broadly triangular ligament pit. Thirteen chevron-shaped teeth in each series.

Dimensions. Length 7·25 mm., height 4·25 mm.

Holotype. M.U.G.D. 1779, paratype 1780; hypotype A.U.C.D., Tate Coll. T.1028.

Type Locality. Bird Rock, Torquay; Jan Juk Formation.

Material. One tablet marked "*Leda embolos*" with 13 topotypes Spring Creek, 2 specimens Fyansford, 3 Snapper Point, one River Murray, one Belmont, one Table Cape.

Stratigraphical Range. Oligocene to Miocene.

Subgenus SCAEOLEDA Iredale, 1929

Scaeoleda Iredale, 1929, Rec. Aust. Mus., 17 (4), 158.

Type species (o.d.) *Leda crassa* Hinds.

Nuculana (Scaeoleda) acinaciformis (Tate).

(pl. 2, figs. 7, 8)

Leda acinaciformis Tate, 1886, p. 130, pl. 5, figs. 6a-6b.
Nuculana acinaciformis Tate (sp.). Harris, 1897, p. 349.

Diagnosis. A moderate sized *Scaeoleda,* acutely rostrate, with strong concentric rounded ribs, about 3 per mm. Twelve chevron-shaped and up to 5 immature teeth in each series.

Description. Shell of moderate size, moderately compressed, elongate-subovate, umbo subcentral, anterior side sharply rounded, posterior side acutely rostrate, dorsal margin gently convex anteriorly and slightly concave posteriorly, curved upwards at the posterior end; ventral margin strongly arched. A strongly defined narrow triangular rostral area extending from the umbo to the posterior-ventral margin. Lunule lanceolate, longitudinally ribbed.

Surface sculptured with strong concentric rounded ribs, about 3 per mm., which are directed upwards and separated by grooves narrower than the ribs. Ribs interrupted at the margin of the rostral area.

Hinge line gently arched with 2 chevron-shaped teeth and up to 5 immature teeth on either side of a broad deeply set triangular chondrophore.

Dimensions. Holotype length 17·5 mm., height 8·5 mm., inflation (one valve) 3 mm. Largest paratype length 21 mm., height 10 mm.

Holotype. A.U.G.D., Tate Coll. T.1033A.

Material. The holotype and 22 paratypes on tablet T.1033 in 5 rows, the holotype being the left-hand specimen in the lowermost row.

Type Locality. Muddy Creek, Hamilton, Victoria. ? Grange Burn Coquina, Lower Pliocene.

Stratigraphical Range. Lower Pliocene.

Nuculana (Scaeoleda) woodsi (Tate).

(pl. 3, figs. 5, 6)

Leda inconspicua Tenison Woods, 1879, p. 239, pl. 21, fig. 3 (*non* A. Adams).
Leda woodsi Tate, 1886, p. 133, pl. 9, fig. 8.
Nuculana woodsi Tate (sp.) Harris, 1897, p. 349.
Nuculana (Scaeoleda) woodsi (Tate). Ludbrook, 1955, p. 20, pl. 1, fig. 5.

Diagnosis. A small compressed *Scaeoleda,* only moderately acuminately rostrate, sculpture of 5 to 8 ribs per mm., about 17 teeth in the posterior series and 26 in the anterior series.

Description. Shell small, compressed, elongate-subovate, inequilateral, umbones situated a little to the posterior, small, and only slightly inflated. Anterior side rounded and somewhat attenuated; posterior side slightly longer than anterior side and moderately acuminately rostrate, dorsal margins nearly straight, ventral margin gently rounded. A well-defined rather broad triangular rostral area extends from the umbo to the posterior ventral margin. Lunule lanceolate, longitudinally ribbed.

Sculpture of fine concentric ribs on the hypotype and generally about 6 per mm. but varying in some specimens from 5 to 8 per mm.; ribs directed upwards and separated by grooves about equal to the ribs, the ribs are weaker on the anterior of the shell.

Hinge strong and gently arched with about 17 close-set chevron-shaped teeth in the posterior series and 26 in the anterior series separated by a narrow deep triangular chondrophore.

Dimensions. Length 12·5 mm., height 6·5 mm., inflation (both valves) 3·5 mm.

Holotype. A.U.G.D., Tate Coll. T.1039J (both valves); Paratype T.1039A (figured pl. 3, fig. 6).

Material. The holotype and 18 paratypes on tablet in three rows. The holotype is a complete specimen marked J, the first on the left of the middle row; the figured paratype marked A is the first on the left of the top row. Holotype and 11 paratypes from Muddy Creek. Two paratypes Table Cape, 3 Spring Creek, 3 Morgan. The specimen from Muddy Creek figured by Tenison Woods as *Leda inconspicua* Reeve is Australian Museum No. F.1800.

Type Locality. Muddy Creek, Hamilton, ? Muddy Creek Marls, Miocene.

Stratigraphic Range. Oligocene to Pliocene.

Observations. *Leda inconspicua* Tenison Woods is practically identical with Tate's immature paratype T.1039D.

Genus Ovaleda Iredale, 1925

Ovaleda Iredale, 1925, Rec. Aust. Mus., 14 (4), 248, 250.

Type species (o.d.) *Sarepta* (?) *tellinaeformis* Hedley = *Leda obolella* Tate

Ovaleda obolella (Tate).

(pl. 3, figs. 1, 2)

Leda obolella Tate, 1886, p. 129, pl. 5, figs. 3a, 3b.
Nuculana obolella Tate (sp.) Harris, 1897, p. 352.
Sarepta (?) *tellinaeformis* Hedley, 1901, pp. 26-27, fig. 8.
Ovaleda tellinaeformis Hedley. Iredale, 1925, p. 250.
Sarepta obolella (Tate). Chapman and Singleton, 1927, p. 116, pl. 10, figs. 2-7.

Diagnosis. An *Ovaleda* of moderate size with a broadly triangular chondrophore with a narrow vertical triangular resilifer. Fifteen to eighteen hinge teeth on either side.

Description. Shell of moderate size, thin and fragile, ovate-quadrate slightly inequilateral, moderately inflated. Posterior margin bluntly rostrate and rounded; anterior margin roundly truncated, dorsal margin gently sloping from a low angle at the umbo. Ventral margin well rounded. Umbones very small, subcentral, situated slightly to the anterior, slightly recurved. Surface smooth but for close fine concentric striae covering the whole shell. Interior smooth; adductor impressions inconspicuous, the posterior small and subtriangular, the anterior larger and somewhat pear-shaped; pallial line entire. Hinge plate narrow, slightly arched at a very low angle with a broad shallow triangular chondrophore supporting a narrow vertical triangular resilifer extending to the umbo. Hinge with two series of small teeth, on the lectotype 15 in the posterior series of which the 7 near the umbo are more or less curved, the 8 further from the umbo chevron-shaped; 19 in the anterior series of which the 11 near the umbo are more or less curved, the 8 further from the umbo chevron-shaped.

Dimensions (Lectotype). Length 11·5 mm., height 9·5 mm.

Lectotype (here designated). A.U.G.D., Tate Coll. T.1035A.

Type Locality. Muddy Creek, Hamilton, Victoria; ? Muddy Creek Marls.

Material. The lectotype and 11 paratypes on tablet labelled *Leda obolella* Tate. Lectotype and 3 paratypes in the top row from Muddy Creek, in the second row specimen D from Gellibrand River, specimen E from Spring Creek. Of 6 specimens in bottom row 3 are from River Murray, 1 from Fyansford, 1 from Balcombe Bay, and 1 from an unspecified locality.

Two paratypes A.M. C8959 *Sarepta tellinaeformis* Hedley, a number of small specimens A.M. 13243 of the Thetis series examined by Hedley and identified as and labelled *Sarepta obolella* Tate, 3 specimens A.M. C48115 of *Sarepta tellinaeformis* including the hypotype figured by Chapman and Singleton from 33-56 fathoms off Botany Heads.

Stratigraphic Range. Miocene and Recent.

Observations. Like Hedley and Chapman and Singleton, I am unable, in the absence of sufficient material for statistical study, to find any specific characters to distinguish *tellinaeformis* from *obolella*, and in agreement with Chapman and Singleton have included the Recent species in the synonymy. Although I have not seen the type species of *Sarepta*, I have accepted the opinion of Powell (1935, p. 252) that "in its thin rounded shell *Ovaleda* resembles *Sarepta*, but differs in having feeble traces of a rostrum and a small broadly triangulate chondrophore with a normal resilium, quite unlike the narrow oblique resilium of *Sarepta*".

Ovaleda planiuscula (Tate).

(pl. 3, figs. 3, 4)

Leda planiuscula Tate, 1886, p. 130, pl. 5, fig. 2.

Sarepta planiuscula (Tate). Chapman and Singleton, 1927, p. 116, pl. 10, figs. 8-12.

Diagnosis. A very small fragile rather flat *Ovaleda* with about 9 teeth on the anterior side, 5 on the posterior.

Description. Shell very small, thin, very fragile, flattish, roundly quadrate, slightly inequilateral, slightly produced and rounded posteriorly, roundly truncated anteriorly. Dorsal margin very gently arcuate, ventral margin gently rounded. Surface smooth but for fine concentric striae, interior smooth, adductor impressions weak. Umbo subcentral. Hinge plate very narrow, with 9 small chevron-shaped teeth in the anterior series and 5 in the posterior series; chondrophore broadly triangulate, nature of the resilifer uncertain, as with the exception of the figured paratype (pl. 3, fig. 4) the fragile specimens are too firmly stuck on the tablet for safe handling.

Lectotype (designated Chapman and Singleton, 1927). A.U.G.D., Tate Coll. T.1009A.

Type Locality. "Adelaide Bore", Kent Town. Upper Eocene.

Material. The lectotype and 4 paratypes A-E mounted on tablet T.1009.

Stratigraphical Range. Known only from subsurface material of Upper Eocene age intersected in the Kent Town Bore.

Genus LEDELLA Verrill and Bush, 1897

Ledella Verrill and Bush, 1897, Amer. Journ. Sci., 4 (3), 54.

Type species (o.d.) *Leda messanensis* Seguenza

Ledella leptorhyncha (Tate).

(pl. 1, figs. 3, 4)

Leda leptorhyncha Tate, 1886, p. 131, pl. 10, figs. 5a-5b

Nuculana leptorhyncha Tate (sp.) Harris, 1897, p. 350.

Diagnosis. A minute ovate-pyriform *Ledella* sculptured with fine concentric threads on the middle and ventral portions, obsolete on the rest of the shell. Thirteen chevron-shaped teeth in both the anterior and posterior series.

Description. Shell minute, ovate-pyriform, ventricose, inflated in the middle, conspicuously compressed and rostrate posteriorly; umbones subcentral, slightly elevated and opisthogyrate, anterior margin rounded, posterior margin acuminate-rostrate, anterior dorsal slope nearly straight, posterior dorsal slope slightly concave, ventral margin evenly convex except for a fairly broad insinuation immediately below the rostrum. Rostrum unicarinate, only slightly elevated. Surface sculptured with concentric threads and microscopic striae. The threads are strongest on the middle of the shell and ventrally; they become obsolete dorsally and both anteriorly and posteriorly. Hinge strong, with 13 chevron-shaped teeth on either side of a small broadly-triangular well-defined chondrophore.

Dimensions. Lectotype length 5·25 mm., height 3·1 mm., inflation 2·5 mm.

Lectotype (here designated). A.U.G.D. T.1041A.

Type Locality. Blanche Point Marls, Blanche Point, Aldinga Bay.

Material. The lectotype and 8 paratypes all of which are complete (both valves) and 3 paratypes which are incomplete. Paratype T.1041L, showing the internal features, is figured (pl. 1, fig. 3). Three topotypes G.S.S.A. 1/60/1. Six specimens Adelaide Children's Hospital Bore 5, 63-64 feet.

Stratigraphic Range. Blanche Point Marls, Upper Eocene.

Observations. The species is known only from the Blanche Point Marls at their type locality and intersected in Adelaide (Kent Town) Bore and foundation test bores at Adelaide Children's Hospital. On his original tablet Tate has not indicated which specimens are from Blanche Point and which from Adelaide Bore. It cannot be said with certainty that the lectotype is the specimen figured by Tate as two specimens are missing from the tablet, the first on the left hand of the top row and the third in the second row. The lectotype is very close to the original figure, but from its relatively bleached appearance it is almost certainly from Blanche Point and not from the bore.

Ledella praelonga (Tate).

(pl. 1, figs. 7, 8)

Leda praelonga Tate, 1886, p. 132, pl. 12, figs. 4a, 4b.
Nuculana praelonga Tate (sp.) Harris, 1897, p. 351.

Diagnosis. A small weakly rostrate *Ledella* which is smooth but for growth striae. Anterior side twice as long as the rostrate posterior side.

Description. Shell very small, transversely subovate, inequilateral, somewhat compressed, smooth but for fine growth striae, which are stronger over the rostrum. Umbo situated at almost the posterior one-third. Anterior side twice as long as posterior, sharply rounded and produced; posterior side shortly and weakly rostrate. Dorsal margin broadly rounded and somewhat angulate at the umbo, ventral margin evenly and broadly convex except for a shallow and weak insinuation just below the rostrum. Hinge strong with 10 chevron-shaped teeth in the posterior series, 13 chevron-shaped teeth in the anterior series, separated by a small subtriangular chondrophore.

Dimensions. Holotype length 4·25 mm., height 2·25 mm., inflation (both valves) 1 mm.

Holotype. A.U.G.D., Tate Coll. T.1040A. Paratype (figured) T.1040B.

Type Locality. Muddy Creek, Hamilton, Victoria. ?Muddy Creek Marls, Miocene.

Material. The holotype and 13 paratypes on tablet. There are three rows at the top of the tablet, the holotype being the middle specimen in the second row and the figured paratype the specimen on the extreme right of the third

row. Except for one valve in the first row marked "2" from Snapper Point and 3 valves marked "T. Cape", all specimens are from Muddy Creek (?Muddy Creek Marls).

There is a second series of 7 specimens in a single row below this, 6 of which marked "1" are from "River Murray" and 2 marked "3" from Spring Creek. Only one from Spring Creek on the extreme right belongs to *L. praelonga*. The other 7 are a distinct and as yet undescribed species well known to me from the Miocene of the Murray Basin.

Stratigraphic Range. Oligocene to Miocene.

Genus Poroleda Hutton, 1893

Poroleda Hutton, 1893, Linn. Soc. N.S.W, Macleay Mem. Vol. 86.

Type species (monotypy) *Scaphula* (?) *lanceolata* Hutton

Poroleda huttoni (Tenison Woods).

(pl. 3, figs. 9, 10)

Leda huttoni Tenison Woods, 1879, p. 239, pl. 21, fig. 2.
Leda huttoni Tenison Woods. Tate, 1886, p. 130, pl. 6, fig. 4.
Nuculana huttoni Tenison Woods. Harris, 1897, p. 351.

Diagnosis. A *Poroleda* with a conspicuous flattened posterior rostral area. Thirteen chevron-shaped teeth in the anterior series, 20 in the posterior, becoming lamellar and imbricating towards the umbo in both series.

Description. Shell depressed, opaque, dull, elongate, subrectangular, slightly rostrate, posteriorly much produced, between the umbo and the posterior margin a triangular flattened rostral area. Umbo very small and but slightly elevated, situated at the anterior one-third. Dorsal margin broadly angulate, slightly convex anteriorly and slightly concave posteriorly; anterior margin narrowly arcuate; posterior margin obliquely truncated; ventral margin gently arcuate.

Hinge line broadly arcuate with 13 chevron-shaped narrow imbricating teeth in the anterior series; 20 narrow imbricating teeth in the posterior row, all chevron-shaped but the two in the posterior series nearest the umbo which are lamellar; the two series separated by a broad triangular chondrophore with a long narrow oblique ligament pit on the posterior side.

Dimensions. Length 12 mm., height 5 mm.

Holotype and one paratype A.M. F.1786; hypotype A.U.G.D., Tate Coll., T.1037.

Type Locality. Muddy Creek, Hamilton, Victoria (? Muddy Creek Marls).

Material. The holotype and paratype A.M. F.1786. Tate's tablet T.1037 with 22 specimens. In the top row 2 marked "1" from Aldinga, the left one of which was figured by Tate; 4 marked "2" from Adelaide (Kent Town) Bore. In the middle of the tablet one specimen ("3") from Table Cape; in the bottom row 13 topotypes from Muddy Creek marked "4" and one marked "5" from Snapper Point.

The two figured hypotypes are (1) the topotype on the extreme left of Tate's tablet, (2) the topotype third from the left in the bottom row. Both are very close to the holotype.

Stratigraphic Range. Upper Eocene (Blanche Point Marls) to Miocene (Muddy Creek Marls).

Observations. Tate figured a specimen from Aldinga (Blanche Point Marls) which is now broken. The Aldinga and Kent Town Bore specimens exhibit recognizable differences from *huttoni* which were noted by Tate (p. 130). The species is variable, however, and there is insufficient material to separate the species with any certainty.

Genus Lamellileda Cotton, 1930

Lamellileda Cotton, 1930, Rec. S. Aust. Mus. 4 (2), 227.

Type species (monotypy) *Lamellileda typica* Cotton

Lamellileda tatei (Hedley).

(pl. 3, figs. 7, 8)

Poroleda lanceolata Tate, 1894, p. 186, pl. 12, fig. 6. (Not *Poroleda lanceolata* (Hutton, 1893) = *Scaphula* (?) *lanceolata* Hutton, 1885.)

Poroleda tatei Hedley, 1904, p. 112 (*nom. mut.* for *P. lanceolata* Tate).

Diagnosis. A subrectangular *Lamellileda* with seven imbricating lamellar teeth in the posterior and seven in the anterior series.

Description. Left valve only. Shell depressed, opaque, shining, sculptured with microscopic concentric striae, elongate-subrectangular, posteriorly much produced, abruptly and somewhat squarely truncated. Dorsal margin nearly straight; slightly convex anteriorly and slightly concave posteriorly; anterior margin rounded, posterior margin straight; ventral margin gently arcuate. Umbo small but elevated, situated at the anterior one-fourth. Hinge line nearly straight, with 7 long lamellar teeth in the narrow posterior series, 7 shorter and also lamellar teeth in the anterior series separated by a broad triangular chondrophore with a deep long and narrow oblique ligament pit on the posterior side.

Dimensions. Length 11·7 mm., height 3·9 mm.

Holotype. A.U.G.D., Tate Coll. T.1001.

Type Locality. Gelibrand River, Victoria.

Material. The holotype only.

Stratigraphic Range. ? Gelibrand Clays, Miocene.

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EXPLANATION OF PLATES

PLATE 1

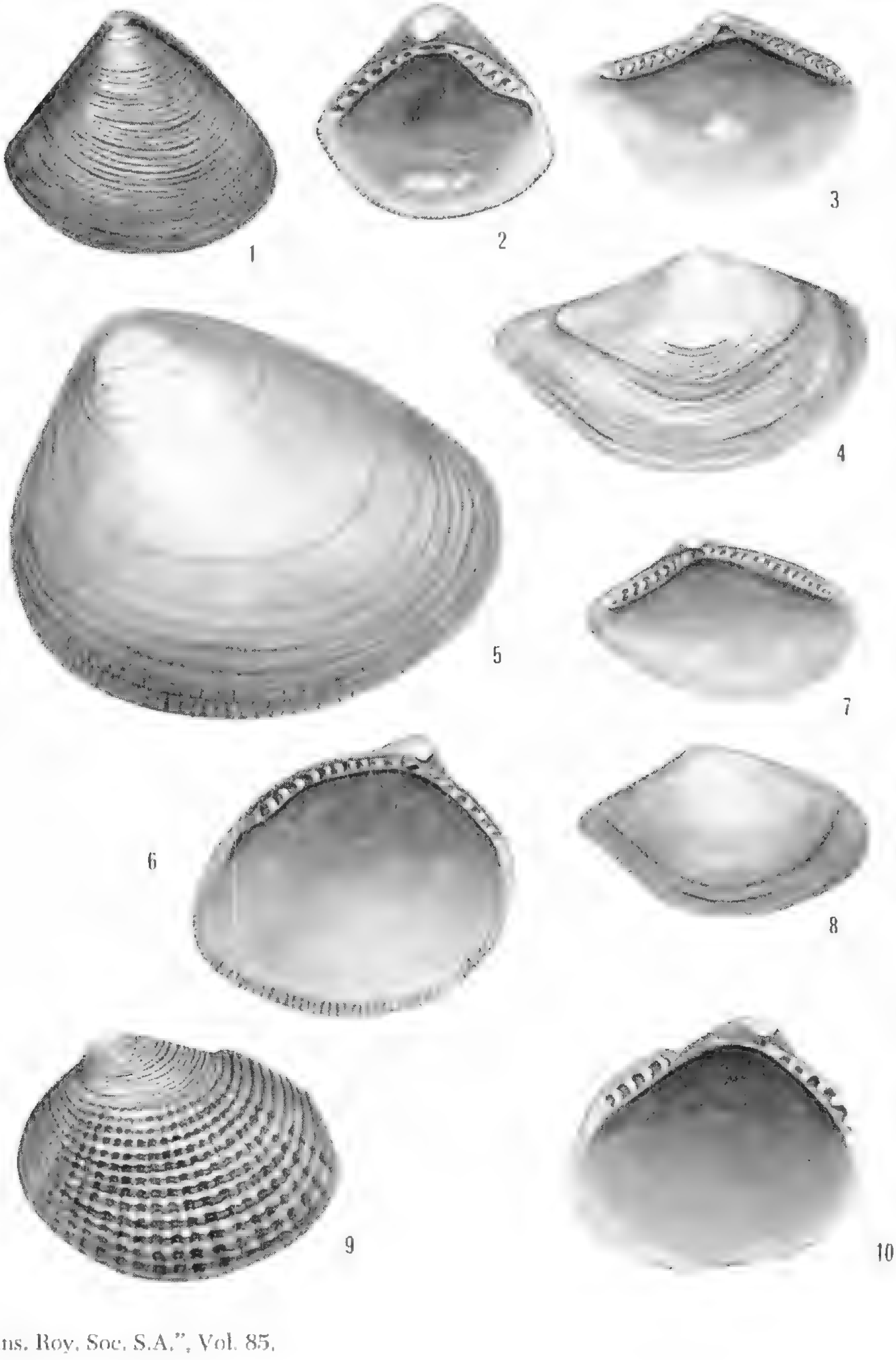
Fig. 1. *Pronucula morundiana* (Tate). Holotype T.1042, x 12·5.
Fig. 2. *Pronucula morundiana* (Tate). Paratype T.1042, left valve, interior, x 12·5.
Fig. 3. *Ledella leptorhyncha* (Tate). Paratype T.1041L, left valve, interior, x 10.
Fig. 4. *Ledella leptorhyncha* (Tate). Lectotype T.1041A, right valve, exterior, x 10.
Fig. 5. *Pronucula tatei* (Finlay) = *Nucula semistriata* Tate. Holotype T.1045, x 12·5.
Fig. 6. *Pronucula tatei* (Finlay) = *Nucula semistriata* Tate. Paratype T.1045, right valve, interior, x 12·5.
Fig. 7. *Ledella praelonga* (Tate). Paratype T.1040B, left valve, interior, x 10.
Fig. 8. *Ledella praelonga* (Tate). Holotype T.1040A, right valve, exterior, x 10.
Fig. 9. *Pronucula fenestralis* (Tate). Holotype T.1044, right valve, exterior, x 20.
Fig. 10. *Pronucula fenestralis* (Tate). Holotype T.1044, right valve, interior, x 20.

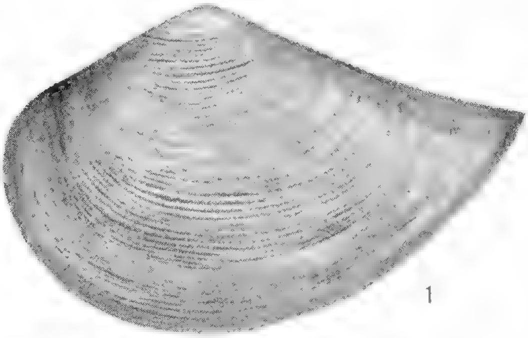
PLATE 2

Fig. 1. *Nuculana (Saccella) chapmani* Finlay = *Leda apiculata* Tate. Holotype T.1036A, side view, x 7·5.
Fig. 2. *Nuculana (Saccella) chapmani* Finlay = *Leda apiculata* Tate. Holotype T.1036A, dorsal view, x 7·5.
Fig. 3. *Nuculana (Saccella) fontinalis* (Pritchard). Hypotype, T.1028A, exterior, x 7·5.
Fig. 4. *Nuculana (Saccella) fontinalis* (Pritchard). Hypotype T.1028B, interior, right valve, x 7·5.
Fig. 5. *Pronucula tatei* (Finlay) = *Nucula semistriata* Tate. Holotype T.1045, x 12·5. interior, right valve, x 5.
Fig. 6. *Nuculana (Saccella) vagans* (Tate) = *Leda lucida* T. Woods. Hypotype T.1034A, exterior, right valve, x 3·2.
Fig. 7. *Nuculana (Scaeoleda) acinaciformis* (Tate). Paratype T.1033B, exterior x 5.
Fig. 8. *Nuculana (Scaeoleda) acinaciformis* (Tate). Paratype T.1033B, interior, x 5.

PLATE 3

Fig. 1. *Ovaleda obolella* (Tate). Lectotype T.1035A, external view, x 5.
Fig. 2. *Ovaleda obolella* (Tate). Lectotype T.1035A, internal view, x 5.
Fig. 3. *Ovaleda planiuscula* (Tate). Lectotype T.1009A, external view, x 10.
Fig. 4. *Ovaleda planiuscula* (Tate). Paratype T.1009E, internal view, x 15.
Fig. 5. *Nuculana (Scaeoleda) woodsi* (Tate). Holotype T.1039J, x 5.
Fig. 6. *Nuculana (Scaeoleda) woodsi* (Tate). Paratype T.1039A, left valve, internal view, x 5.
Fig. 7. *Lamellileda tatei* (Hedley) = *Poroleda lanceolata* Tate. Holotype T.1001, external view, x 7.
Fig. 8. *Lamellileda tatei* (Hedley) = *Poroleda lanceolata* Tate. Holotype T.1001, internal view, x 7.
Fig. 9. *Poroleda huttoni* T. Woods. Hypotype T.1037C, right valve, internal view, x 7·5.
Fig. 10. *Poroleda huttoni* T. Woods. Hypotype T.1037B, right valve, external view, x 7·5.

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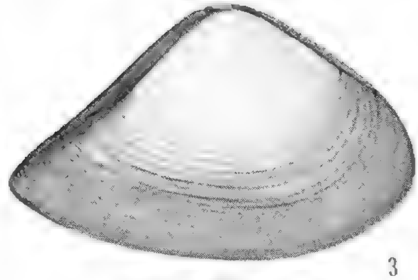
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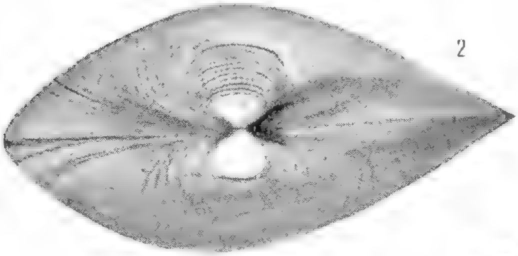
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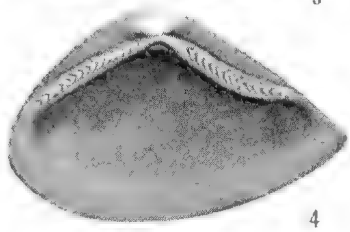
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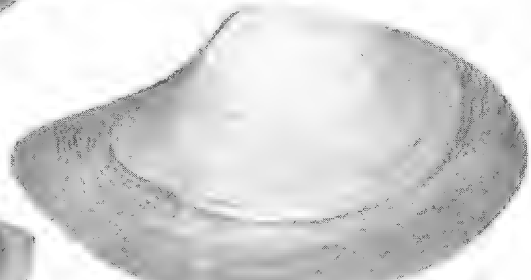
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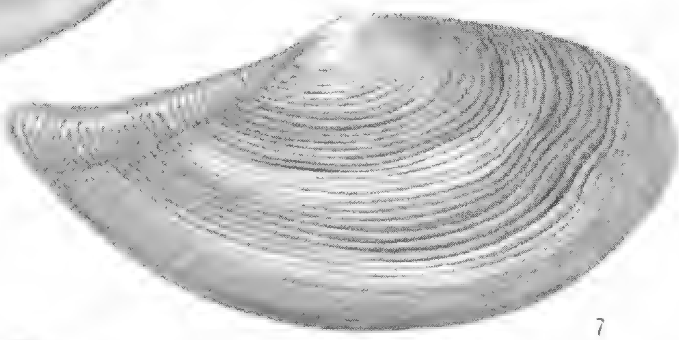
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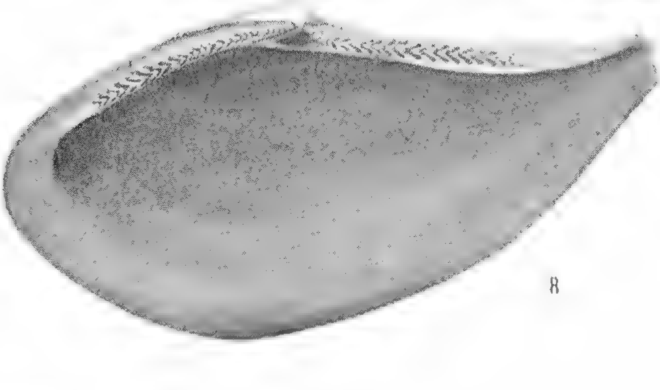
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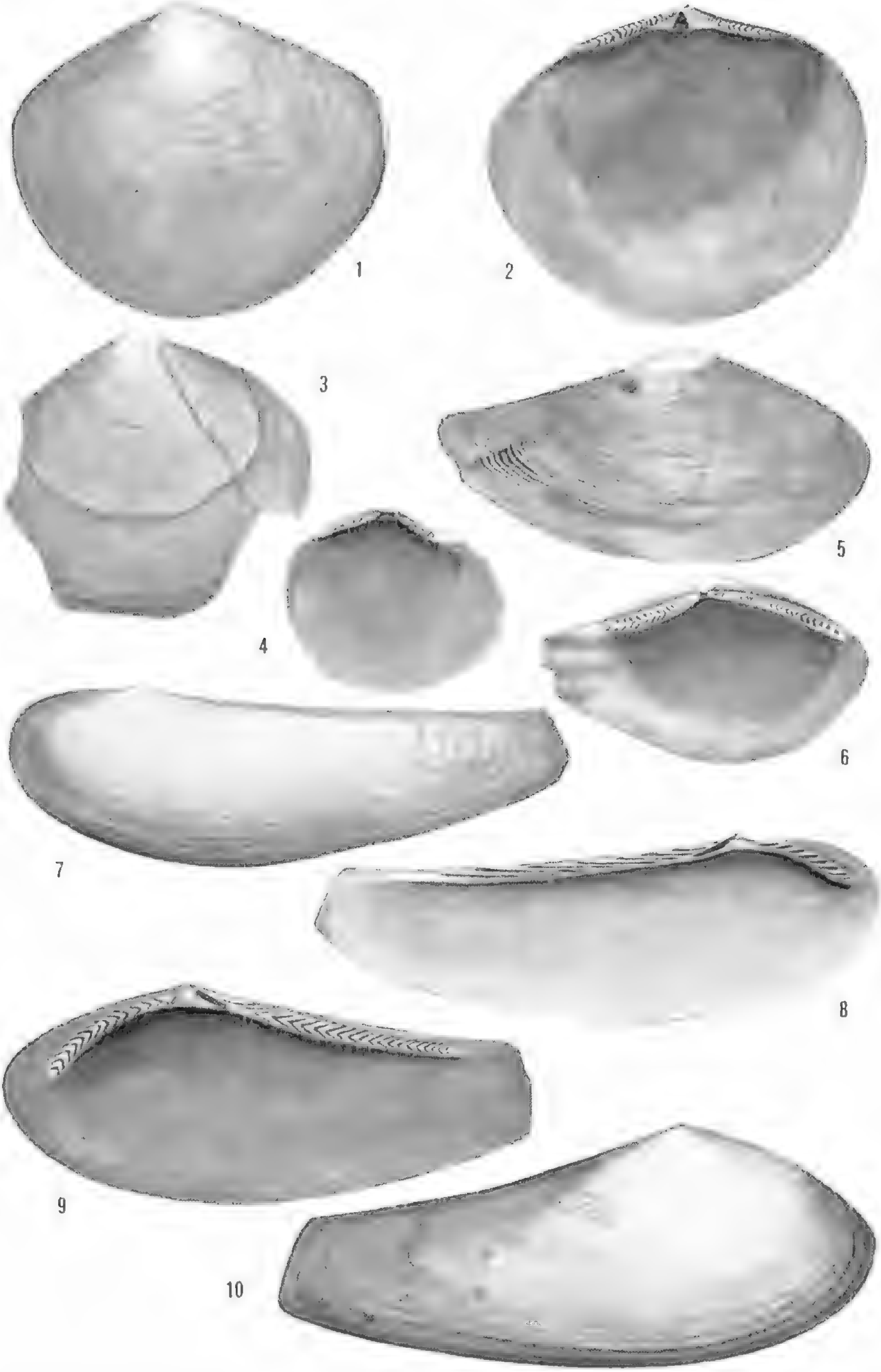
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PERMIAN TO CRETACEOUS SUBSURFACE STRATIGRAPHY BETWEEN LAKE PHILLIPSON AND THE PEAKE AND DENISON RANGES, SOUTH AUSTRALIA

BY N. H. LUDBROOK

Summary

Examination of seven old water bores sunk between 1887 and 1920 in the area between Lake Phillipson and the north-south railway line has established a well-defined Lower Permian sequence of glacigene boulder clays, marine siltstones and clays, and freshwater mudstones and siltstones with low rank coals. The sequence has a maximum thickness of approximately 3,000 feet and ranges in age, determined from plant spores, from (?) lowermost Sakmarian to Lower Artinskian. The glacigenes at the base of the Permian rest on Precambrian rocks; the sequence is overlain by kaolinitic sands of undetermined age, tentatively Jurassic, and Aptian marine shales and mudstones.

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by N. H. Ludbrook*

[Read 11 May 1961]

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Examination of seven old water bores sunk between 1887 and 1920 in the area between Lake Phillipson and the north-south railway line has established a well-defined Lower Permian sequence of glacigene boulder clays, marine siltstones and clays, and freshwater mudstones and siltstones with low rank coals. The sequence has a maximum thickness of approximately 3,000 feet and ranges in age, determined from plant spores, from (?) lowermost Sakmarian to Lower Artinskian. The glacigenes at the base of the Permian rest on Precambrian rocks; the sequence is overlain by kaolinitic sands of undetermined age, tentatively Jurassic, and Aptian marine shales and mudstones.

1. INTRODUCTION

The area considered in this report lies in the centre of South Australia, in the north-eastern part of the Central Province (Dunlop and Parkin, 1958, p. 71) roughly between Lake Phillipson on the west, and the Peake and Denison Ranges on the north-east, and Coward on the south-east. It has also been described as part of the south-western portion of the Great Australian Artesian Basin (Fig. 1).

Although exploratory drilling for underground water commenced as early as 1881 at Anna Creek, the subsurface stratigraphy of the area was known only in very general terms until quite recently. Re-examination of cores and sludges from old bores was not possible until 1959 when they were found stored in a basement of the Engineering and Water Supply Department and subsequently transferred to the Mines Department. Only government bores are represented in the collection.

The present report presents lithological and palaeontological data from microexamination of all available cores and sludges from Lake Phillipson, Stuart Range No. 1, Stuart Range No. 2, Boorthanna (Duff Creek), Anna Creek, Coorie Appa, and Margaret Creek Bores.

2. PREVIOUS WORK

Lithological logs of most of the bores were published in annual reports of the Engineer-in-Chief for the years in which the bores were sunk.

The presence of coal directed most interest towards Lake Phillipson Bore, of which stratigraphic interpretations were subsequently published first by Brown (1905, p. 6), who implied that the bore in progress at 3117 feet was still in Cretaceous sediments similar to those of the Great Artesian Basin. A contrary view was apparently held by the Conservator of Water at the time (see Appendix I). Howchin (1928, p. 212) suggested a Triassic (or Jurassic) age for the interval 1400 to 1950 feet in Boorthanna Bore. Jack (1930, p. 10,

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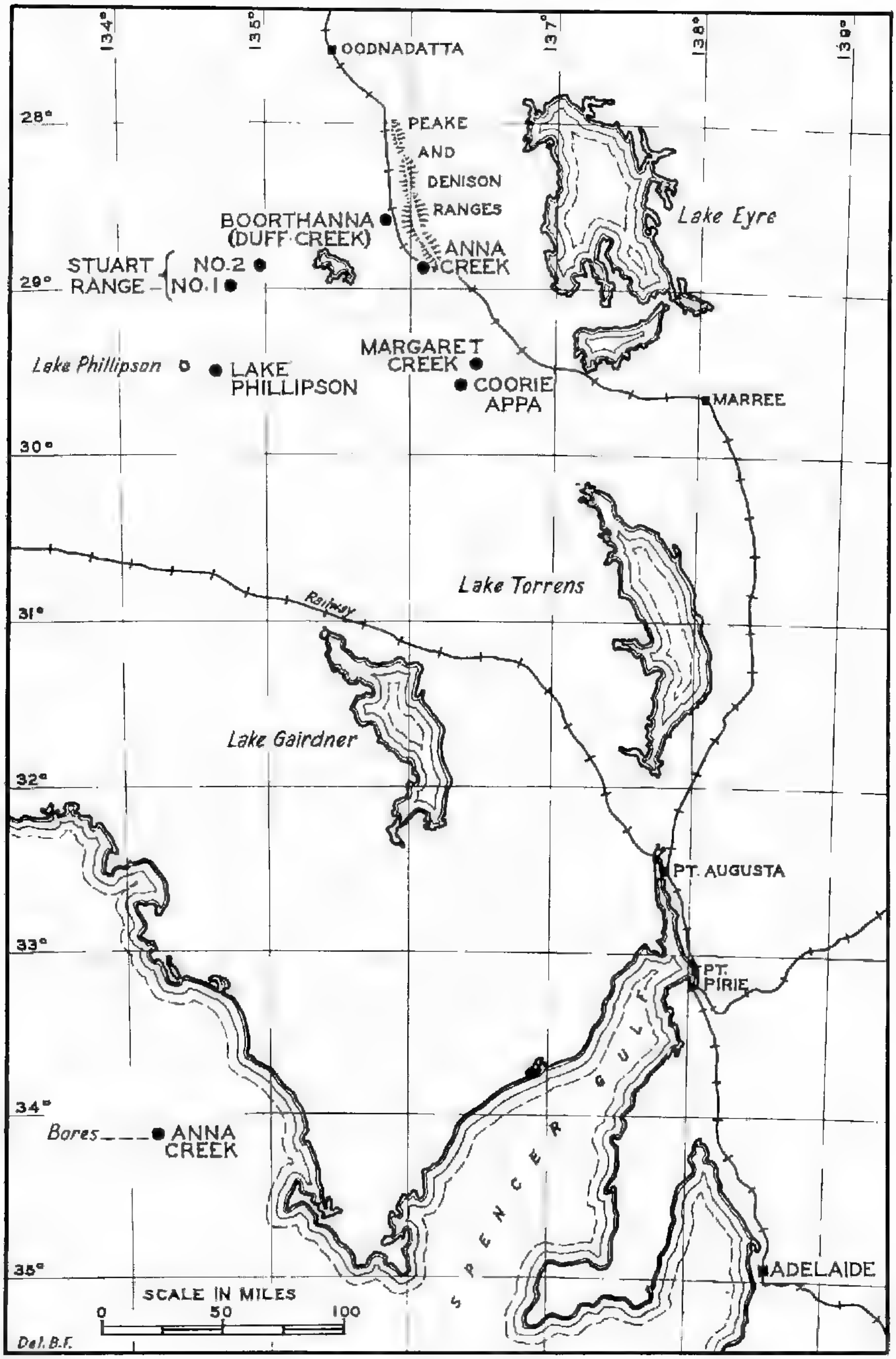

Fig. 1. Locality plan of bores.

pl. 2, pl. 3) correlated the coal measures in Lake Phillipson with the Triassic Leigh Creek Coal Measures, and recognized the possibility of pre-Jurassic beds in Boorthanna. Ward (1946, p. 64) and Campana and Wilson (1955, p. 27) did not differ significantly from Jack, while Chugg (1957, p. 7) referring mainly to Boorthanna considered the possibility of a glacial origin for most of the Boorthanna sediments. Dickinson (1952, p. 89) interpreted the analysis of coal in Lake Phillipson as signifying a post-Triassic age for the coal-bearing strata.

It was not until a suite of samples from Lake Phillipson was sent to Mr. B. E. Balme of the University of Western Australia that a firm basis for correlation was established (Balme, 1957, pp. 61-62) and the presence of over 2000 feet of Permian sediments was recognized in Lake Phillipson Bore.

The Lower Permian sequence established by Mr. Balme for Lake Phillipson Bore provides the background for the present study.

At the end of 1960 at the request of Clarence River Oil Exploration Ltd. and Exoil Pty. Ltd. the writer began examining for microfossils all available deep bores in the area. Simultaneously with the commencement of the work, Mr. W. J. Greer of Delhi Australian Petroleum Ltd. informed the writer that on June 10, 1960, Mr. J. Harrison of Delhi Australian Petroleum Ltd. had noted "traces of forams" between 2280 and 2300 feet when logging Lake Phillipson Bore. This was the first indication of a marine horizon in the Permian of the bore and greatly stimulated the search for foraminifera in other wells which might intersect the Permian west of the Peake-Denison ridge and the north-south railway line.

The generous cooperation of Mr. B. E. Balme throughout the investigation is most gratefully acknowledged.

3. STRATIGRAPHIC SEQUENCE

The stratigraphic sequence penetrated in the seven bores examined is well defined and consists of the following units:

	Maximum thickness feet
Lower Cretaceous	
Aptian mudstones and limestone	220
"Jurassic" (age uncertain)	
Non-marine gritty and kaolinitic sands	247
Lower Permian	
(a) Lower Artinskian to Upper Sakmarian freshwater mudstones with coal and some sandstone	264
(b) Sakmarian freshwater carbonaceous siltstones and mudstones with some sandstone	1830
(c) Lower Sakmarian marine mudstones and siltstones	288
(d) Glacigene boulder clays of presumed lowermost Sakmarian age	766
? Palaeozoic or Proterozoic dolomitic grit	—
Proterozoic chocolate shale and sand	—
Granite basement	—

4. GRANITE BASEMENT

Lake Phillipson Bore was the only well to penetrate to basement. At 3140 the boring entered pegmatitic granite. Drilling continued to 3161 feet in this granite "to satisfy the Government Geologist" (see Appendix I).

5. PROTEROZOIC CHOCOLATE AND GREY SHALE AND SAND

At 1104 feet Coorie Appa Bore entered blue-grey and then chocolate shales with buff incoherent sand beds lithologically similar to those intersected in the deeper bores at Maralinga (Ludbrook, 1961). These are considered to be non-marine sediments of the Marinoan Series. Drilling was continued to 1858 feet in the series.

6. PALAEOZOIC OR PROTEROZOIC DOLOMITIC GRIT

The bedrock of Anna Creek Bore is a crystalline rock consisting of felspar and quartz grains in a dolomitic matrix. Petrological description of this rock is contained in Australian Mineral Development Laboratories reports P 25/61, P 26/61.

7. LOWER PERMIAN

(1) *Boulder clays*

The lowermost beds of the Permian are boulder clays intersected in Lake Phillipson between 2438 and 3140 feet, Coorie Appa between 270 and 1104 feet, and below 149 feet in Margaret Creek Bore. They exhibit a characteristic light blue-grey colour when being washed and mostly carry pebbles and boulders from various sources. In Margaret Creek Bore the glacigenes have chocolate shale bands similar to those at Hallett Cove and in Minlaton Bore, Yorke Peninsula, where the glaciers travelled over chocolate shales of the Upper Proterozoic.

The age of the glaciation may at present be dated only from the marine horizon at the top, regarded by Mr. Balme as of probable Lower Permian (Lower Sakmarian) Age. Foraminifera have so far been found only within the upper part of the glacigenes at 2438 feet in Lake Phillipson Bore as in Minlaton Bore. In Stansbury Bore they also occur near the base of the boulder clays.

If the glacigenes are to be regarded as Permian, they may at present be placed in the lowermost Sakmarian.

(2) *Lower Sakmarian marine mudstones and siltstones*

In upward sequence the boulder clays give way to marine partly calcareous mudstone and siltstone marked at first by the occurrence of occasional foraminifera, principally *Ammodiscus* and *Hyperammina*. For the most part, the foraminifera are poorly preserved arenaceous species representing a very cold water environment. Considering the small amount of core or sludge available for examination they are fairly abundant at certain levels. The most abundant assemblage occurred in the glauconitic siltstones at 2088 feet at the bottom of Boorthanna Bore where an assemblage dominated by *Hyperammina acicula* (Parr) contained cf. *Hippocrepinella biaperta* Crespin, *Thuramminoides phialaeformis* Plummer, *Ammodiscus oonahensis* Crespin, cf. *Ammovertella inclusa* (Cushman and Waters), *Ammobaculites* cf. *woolnoughi* Crespin and Parr, *Trochammina* spp., and (?) *Polytaxis* sp.

The mudstones in which they occur in Lake Phillipson Bore are too compacted and do not break down readily enough in water for the foraminifera to be easily recovered without damage. Their abundance may be judged from the fact that they are easily visible under the microscope on the surface of the core fragments.

The marine horizon occurs between 2269 and 2438 feet in Lake Phillipson, 1800 and 2088 feet in Boorthanna and between 30 and 270 feet in Coorie Appa. It is also probably represented between 711 and 802 feet in Anna Creek where

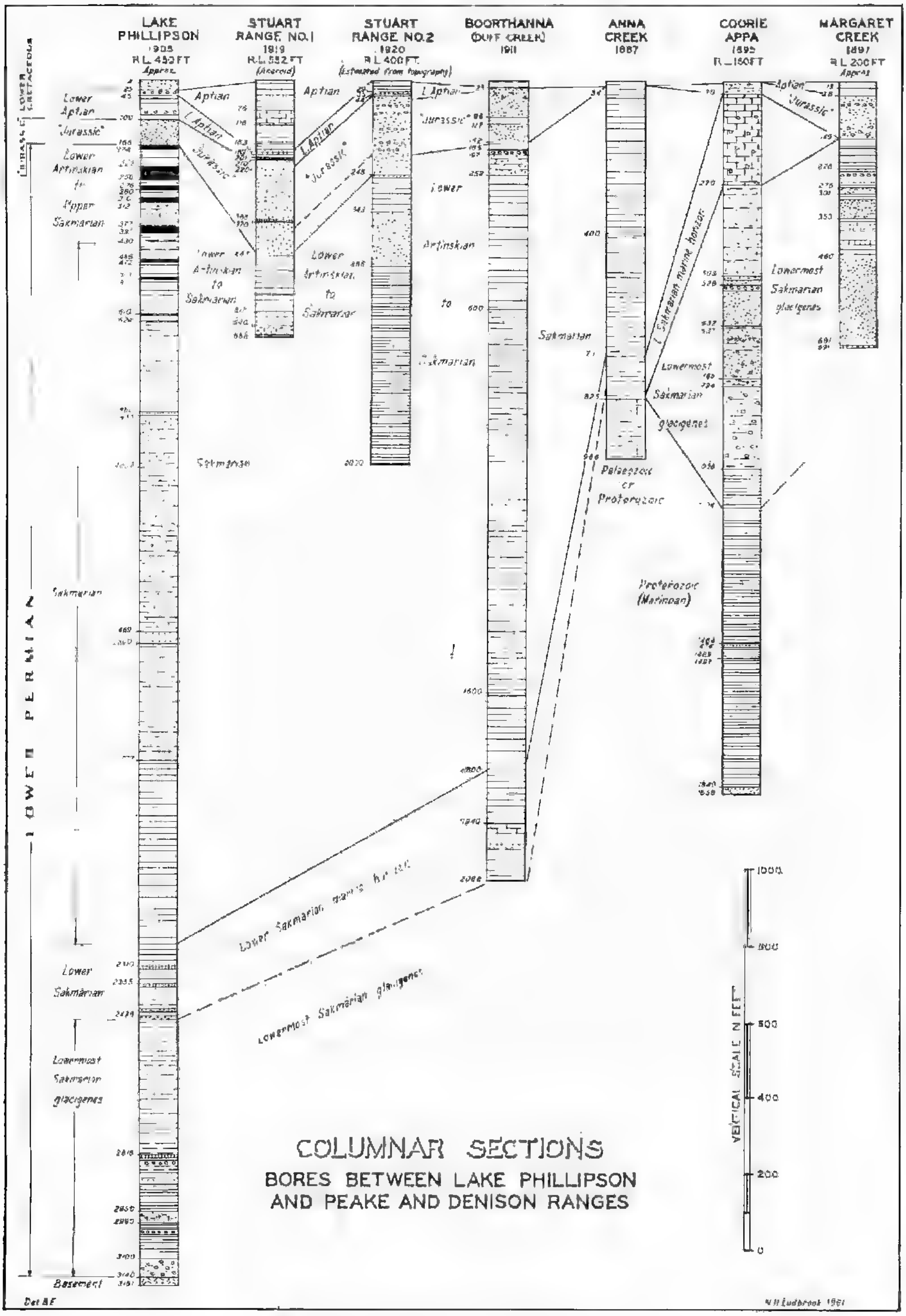

Fig. 2. Columnar sections of bores.

unidentified spines and teeth occur in calcareous carbonaceous sandstone and siltstone. Unfortunately, very little core is available from this bore, from which the drillers logged "clay rock and shells" between 771 and 784 feet. Both the spines and teeth may belong to freshwater vertebrates.

(3) *Sakmarian freshwater carbonaceous siltstones and mudstones with some sandstone*

Above the marine horizon there occurs a fairly monotonous sequence of highly carbonaceous siltstones and mudstones with an abundant microflora. Washings of the mudstones in the interval usually carry large megaspores which Mr. Balme has tentatively identified in correspondence as lycopod megaspores close to a form described from the Lower Permian of Brazil and the Belgian Congo.

The interval represented from 430 to 2269 feet in Lake Phillipson Bore was tentatively dated as Sakmarian equivalent to part of the Grant Formation (Balme, 1957, p. 62).

(4) *Lower Artinskian to Upper Sakmarian freshwater mudstones and sandstone with coal*

The uppermost part of the Lower Permian sequence is best represented in Lake Phillipson Bore between 166 and 430 feet by mudstones, shales and fine sandstones interbedded with low rank coal. No coal bands occur in any of the other bores, but the interval is probably represented below 447 feet in Stuart Range No. 1, below 248 feet in Stuart Range No. 2 and between 162 and about 400 feet in Boorthanna.

8. NON-MARINE GRITTY SANDS AND KAOLINITIC SANDS OF UNCERTAIN AGE ("JURASSIC")

The Lower Permian beds are overlain by buff and light grey kaolinitic sands and gravel characterized by abundant grey quartz grit and pebbles. The age of these sediments is not known with certainty as they are apparently completely unfossiliferous. They have been mapped as Jurassic and doubtfully considered as Permian or Permian reworked in the Mesozoic (Ludbrook, 1961).

9. LOWER CRETACEOUS

Aptian shales, mudstones and limestones equivalent to the lower part of the Roma Formation in the Great Artesian Basin were intersected in Lake Phillipson, Stuart Range No. 1, Stuart Range No. 2, and Margaret Creek, at the top of the section. Except for Stuart Range No. 1 which passed through 220 feet of fossiliferous Aptian, the Lower Cretaceous is thin and represented by less than 80 feet of sediments with a foraminiferal assemblage characteristic of the Lower Aptian: *Haplophragmoides chapmani, Haplophragmoides dickinsoni, Textularia anacooraensis* and associated species. The assemblage is represented abundantly in Lake Phillipson at 87 feet.

Boulder horizons occur within the shales, the origin of which is in some doubt but is at present accepted as representing reworking of Permian glacigenes rather than as evidence of Lower Cretaceous glaciation.

10. EVALUATION OF DATA

The seven bores examined have provided entirely new data on the Lower Permian geological history of a remote part of South Australia. Glaciation commenced in earliest Permian (or late Carboniferous) times and the region was probably extensively glaciated, although only three bores — Lake Phillip-

son, Coorie Appa and Margaret Creek – intersected the boulder clays. Towards the end of the glaciation overdeepening seems to have allowed Lower Sakmarian seas to gain access to the area and the glacigenes with occasional foraminifera near the top grade into marine sediments with fairly abundant arenaceous foraminifera.

The source and mode of entry of the sea is an important problem awaiting solution. Marine Permian sediments occur in a similar way on Yorke Peninsula near the top of the glacigenes intersected in Minlaton (Ludbrook, 1957) and Stansbury Bores, but there is at present no evidence of connection during the Permian between Yorke Peninsula and the Lake Phillipson-Peake and Denison area 450 miles to the north-west with the stable shield of Eyre Peninsula between. The possibility of marine Permian sediments occurring in the South Australian part of the Great Artesian Basin connecting with the Bowen Basin cannot at present be overlooked, but no positive evidence has been obtained so far. The only Permian sediments intersected in Delhi-Frome-Santos Innamincka No. 1 Well were freshwater coal-bearing strata of Upper Permian (Kungurian-Kazanian) age. Unless part of the so-called "Jurassic" kaolinitic sandstones are equivalent to these beds, there is no Upper Permian represented in the present bores.

However, to the west of Lake Phillipson and into Western Australia lies the Officer Basin, as yet completely unexplored below the surface. One is tempted to consider the admittedly remote possibility of Permian sediments occurring in the Officer Basin and connecting by means of a north-westerly trough in the direction of the Wilkinson-Mackintosh Ranges to the Canning Basin.

Marine conditions were succeeded by lacustrine conditions during the Sakmarian grading into coal measures towards the Artinskian. Apparently a rich flora existed at this time.

The columnar sections on Fig. 2 are arranged in order:

(1) from Lake Phillipson to Stuart Range No. 2 along a north-easterly line about 50 miles long;

(2) from Boorthanna to Margaret Creek about 75 miles in a south-south-easterly direction.

II. DETAILS OF THE BORES

Lake Phillipson Bore

Completed 1905

Core Depth (feet)	
0′ 0″– 4′	Red surface soil and kunkar.
4′ – 15′ 4″	Red brown medium ferruginous sand with gypsum.
15′ 4″– 25′ 9″	Fine to coarse red to red-brown sand, gritty at 25 feet, calcareous, with grey, subrounded quartz grains.
25′ 9″– 29′10″	Light grey clay with limonitic nodules and facetted pebbles of quartzite up to 60 mm. long. Washings consist mainly of limonite, a few angular quartz grains, gypsum, some glauconite. There is an assemblage of Aptian arenaceous foraminifera dominated by *Textularia* sp. 4 and *Siphotextularia* sp. 2.
29′10″– 45′	Grey clay with pebbles to 70 mm., all with somewhat flat surfaces, and limonitic layers.
45′ – 60′ 3″	Light grey mudstone with *Haplophragmoides chapmani, Ammobaculites* sp. 3, *Trochammina minuta* and other arenaceous species.
60′ 3″– 73′10″	Cream clay.
73′10″– 100′	Grey mudstone with fine angular quartz grains, limonite, pebbles at 89′9″ and abundant arenaceous foraminifera including *Haplophragmoides chapmani, Haplophragmoides dickinsoni* and *Textularia anacooraensis*. This assemblage occurs in the lower part of the Aptian.

Core Depth (feet)	
100′ – 166′10″	Buff gritty kaolinitic sand with coarse subangular quartz, felspar, coarse grey quartz, fine to medium angular quartz.
166′10″– 174′ 5″	Coal.
174′ 5″– 180′ 2″	Grey carbonaceous mudstone, with fine angular quartz grains, abundant plant remains and fine mica.
180′ 2″– 198′10″	Grey siltstone with abundant fine angular quartz, some coarse grains to grit size, earthy, with carbonaceous matter.
198′10″– 227′ 9″	Grey carbonaceous mudstone.
227′ 9″– 256′ 3″	Coal.
256′ 3″– 276′ 8″	Light grey carbonaceous mudstone with pyrite.
276′ 8″– 280′ 5″	Coal.
280′ 5″– 297′ 1″	Grey carbonaceous mudstone.
297′ 1″– 303′10″	Grey carbonaceous shale.
303′10″– 310′11″	Grey carbonaceous mudstone with fine angular quartz grains, abundant plant remains, muscovite.
310′11″– 312′10″	Coal.
312′10″– 322′	Grey sandy siltstone with abundant angular quartz grains, muscovite, biotite, chlorite, carbonaceous matter.
322′ – 366′	Grey very fine silty sandstone with fine angular quartz grains, muscovite, chlorite, carbonaceous matter, pyrite.
366′ – 377′10″	Light grey fine sandy clay with fine angular quartz grains, carbonaceous matter.
377′10″– 393′ 2″	Coal.
393′ 2″– 427′ 1″	Grey carbonaceous siltstone with fine angular quartz grains, muscovite, and abundant plant remains including lycopod megaspores.
427′ 1″– 430′	Grey carbonaceous mudstone.
430′ – 436′10″	Grey siltstone, very carbonaceous, with abundant plant remains, fine angular quartz grains, mica. Sample effervesces very strongly in sodium carbonate solution. Lycopod megaspores.
436′10″– 451′10″	Grey carbonaceous mudstone consisting when washed almost entirely of fresh-looking brown plant fragments.
451′10″– 466′ 1″	Grey siltstone with pyrite nodules, fine angular quartz grains, earthy carbonaceous matter and fine muscovite.
466′ 1″– 472′ 3″	Coal shale, consisting mostly of earthy coal fragments.
472′ 3″– 483′	Grey carbonaceous sandy siltstone with abundant fine angular quartz grains, coaly matter, some coarse subrounded quartz. Lycopod megaspores.
483′ – 510′ 3″	Dark grey carbonaceous mudstone with pyrite nodules to 115 mm. in length.
510′ 3″– 511′ 3″	Dark grey coal shale.
511′ 3″– 542′ 4″	Light grey mudstone with fine angular quartz grains, abundant muscovite, biotite, chlorite, carbonaceous matter. Lycopod megaspores.
542′ 4″– 610′	Grey siltstone with fine angular quartz grains, carbonaceous matter, muscovite, biotite, chlorite, very fresh plant fragments, pyrite nodules. Lycopod megaspores.
610′ – 624′	Grey irregularly laminated mudstone, fine angular quartz grains, abundant fine muscovite, brown plant fragments. Lycopod megaspores.
624′ – 744′ 6″	Dark grey carbonaceous siltstone with fine angular quartz grains, muscovite, abundant brown plant fragments.
744′ 6″– 863′	Brown-grey carbonaceous siltstone with abundant plant remains, carbonaceous matter, muscovite.
863′ – 870′	Grey medium quartz sandstone with angular interlocking grains, muscovite, chlorite, biotite, carbonaceous matter, silty patches.
870′ –1007′ 6″	Grey hard sandy siltstone with abundant carbonaceous matter, chlorite, flat-bedded with fine angular quartz grains, abundant red brown flecks of limonite.
1007′ 6″–1009′	Grey hard sandstone with fine to medium angular interlocking grains, carbonaceous matter, muscovite.
1009′ –1459′	Brown-grey siltstone, with fine angular quartz grains, carbonaceous matter, muscovite, reddish limonite flecks.
1459′ –1607′	Brown-grey hard sandy carbonaceous siltstone with coarse subrounded quartz grains scattered throughout the brown silty matrix, abundant muscovite; yellowish patches apparently due to less humic matter. Arkosic.

Core Depth (feet)	
1607′ –1777′	Grey carbonaceous siltstone, hard, fine even-grained with fine mica, carbonaceous matter.
1777′ –2216′	Dark grey hard carbonaceous mudstone with small leaf impression, conchoidal fracture at 2060′, abundant carbonaceous matter at 2070′; laminated at 2115′.
2216′ –2269′	Dark grey hard and even-grained siltstone with carbonaceous fragments, pyrite.
2269′ –2283′	Dark grey hard fine even-grained siltstone with carbonaceous fragments in patches, pyritic patches. Scattered *Hyperammina*.
2283′ –2310′	Blue-grey carbonaceous mudstone, compacted, with arenaceous foraminifera, particularly *Hyperammina* scattered fairly abundantly throughout the rock and visible on broken surfaces: cf. *Hippocrepinella* sp., cf. *Hyperammina acicula* (Parr), *Thurammina phialaeformis* Plummer, *Ammodiscus multicinctus* Crespin and Parr, *Ammodiscus nowahensis* Crespin, *Ammovertella inclusa* (Cushman and Waters).
2310′ –2312′	Hard grey compacted calcareous laminated mudstone, fine- and even-grained, with fine silica, clay material and calcite.
2312′ –2340′	Dark grey unstratified hard sandy mudstone with abundant coarse quartz grains in a fine matrix somewhat calcareous, mud pellets, small pebbles, pink garnet.
2340′ –2357′	Light grey compact fine-grained claystone with calcite veinlets, conchoidal fracture.
2357′ –2818′	Blue-grey boulder clay—fine-grained siltstone and claystone with fine quartz grains in a clayey matrix, garnet. *Ammodiscus* at 2438′.
2818′	Grey crystalline limestone sandy in parts with mica, quartz grains.
2818′ –2950′	Grey boulder clay with red sandstone pebbles, grains of quartz scattered irregularly through the matrix, grains of ferruginized quartz.
2950′ –2980′	Grey shale (boulder clay) with calcareous partings abundant grit grains of quartz, red ferruginized quartz grains.
2980′ –2990′	Grey calcareous sandstone with grit size quartz grains in a calcareous cement, pink garnet, iron-stained quartz.
2990′ –3140′	Grey compacted clay with scattered quartz grains, small pebbles mostly from granite bedrock.
3140′ –3161′	Granite basement.

Stratigraphic Summary

0′ – 100′	Lower Aptian (marine).
100′ – 166′10″	"Jurassic" (non-marine).
166′10″– 430′	Lower Artinskian-Upper Sakmarian (freshwater).
430′ – 744′	Sakmarian (freshwater).
744′ –2269′	Lower Sakmarian (freshwater).
2269′ –2357′	Lower Sakmarian (marine).
2357′ –3140′	Lowermost Sakmarian (glacial).
3140′ –3161′	Granite basement.

Stuart Range No. 1
Drilled 1919

Cuttings Depth (feet)	
0′ – 7′	Surface silicified clay and sandstone with some calcite.
7′ – 12′	Brown marine shale, with dark red ferruginized clay with *Bigenerina loeblichae*, *Haplophragmoides* sp. 1, *Verneuilinoides* sp. 1.
12′ – 41′	Light grey mudstone, with ferruginized clay.
41′ – 76′	Light grey mudstone with both ferruginized and grey clay.
76′ – 82′	Light grey kaolinized mudstone.
82′ – 118′	Grey calcareous glauconitic siltstone.
118′ – 163′	Dark grey pyritic, siltstone with calcareous foraminifera including abundant *Bulimina* sp. 2.
163′ – 199′	Dark grey very pyritic siltstone with *Trochammina minuta* and *Marginulina marreensis*.
199′ – 201′	Grey cone-in-cone limestone and siltstone.
201′ – 210′	Dark grey pyritic shale.
210′ – 211′	Grey glauconitic and pyritic siltstone and limestone.
211′ – 220′	Grey mudstone.
220′ – 223′	Fine light grey-brown friable pyritic sand.

Cuttings Depth (feet)	
223′ – 224′ 6″	Buff sand with limonite.
224′ 6″– 295′	Coarse buff sand with rounded pitted grains and angular grains.
295′ – 447′	Gritty and fine kaolinitic sand.
447′ – 458′	Sandstone and coal.
458′ – 611′	Dark grey carbonaceous mudstone with fine quartz grains and carbonaceous matter. Lycopod megaspores.
611′ – 615′	Dark grey carbonaceous micaceous siltstone, sandy and felspathic.
615′ – 668′	Dark grey carbonaceous mudstone with pyrite and lycopod megaspores.

Stratigraphic Summary

0′ – 220′	Aptian (marine).
220′ – 447′	"Jurassic" (non-marine)—may be Permian in part.
447′ – 668′	Lower Artinskian-Sakmarian (freshwater).

Records show this bore as 485 feet deep, but boring continued to 668′ and samples were kept to that level.

Stuart Range No. 2
Drilled 1920

Cuttings Depth (feet)	
0′ – 4′	Red surface clayey soil.
4′ – 16′	Grey gypseous shale, very weathered and ferruginized.
16′ – 29′	Grey kaolinized shale, weathered and ferruginized with subangular quartz, glauconite, kaolin and poorly preserved foraminifera including *Textularia anacooraensis*.
29′ – 33′	Light buff grey mudstone, ferruginized with glauconite and angular quartz and a Lower Aptian foraminiferal assemblage including *Haplophragmoides chapmani* and *Textularia anacooraensis*.
33′ – 44′ 6″	Cone-in-cone limestone and calcareous shale.
44′ 6″– 47′	Grey fine sandstone with brown mineral grains.
47′ – 51′	Grey-brown gritty sandstone.
51′ – 54′	Sandstone and gravel with grains to 10 mm. of blue-grey quartz, pink quartzite.
54′ – 64′	Light buff coarse quartz sand with subangular grains.
64′ – 76′	Coarse gravel with pebbles to 40 mm. of various origins.
76′ – 86′	Light cream-buff kaolinitic sand with medium quartz grains—arkosic.
86′ – 195′	Gravel with miscellaneous pebbles, mostly blue-grey quartz, some facetted, medium subangular quartz, felspar.
195′ – 204′	Light brown sand with fairly well sorted subangular medium quartz grains.
204′ – 220′	Grey-buff gritty sand, kaolinitic, with blue-grey quartz grains, and medium subangular clear quartz.
220′ – 253′	Light grey-buff medium sand with coarse mostly angular to subangular quartz, greyish and clear, pink garnet, siderite, felspar.
253′ – 343′	Grey mudstone, with grit size pebbles of various origins, pyrite, felspar, subangular quartz, garnet, iron minerals, plant fragments, opaline quartz.
343′ – 486′	Grey-buff felspathic sand, with coarse to fine angular to rounded quartz grains, felspar, pyrite.

No samples were kept from below 486 feet.

Stratigraphic Summary

0′ – 44′ 6″	Lower Aptian (marine).
44′ 6″– 253′	"Jurassic" (non-marine)—may be Permian in part.
253′ – 486′	Lower Artinskian-Sakmarian (freshwater).
486′ –1000′	No samples, but presumed Sakmarian.

Boorthanna (Duff Creek)
Drilled 1911

Cuttings Depth (feet)	
0′ – 25′	Chocolate clayey surface soil, with coarse angular quartz grains, ironstone fragments and quartzite.
25′ – 45′	Buff clayey gritty sand with fresh felspar.

Cuttings Depth (feet)	
45′ – 70′	Light red-brown fine clayey sand and grit with fresh felspar and mica.
70′ – 80′	Light brown fine clayey sand.
80′ – 96′	Off-white clayey gritty sand and coarse grit with blue-grey quartz.
96′ – 117′	Grey mudstone with small pebbles.
117′ – 134′	Light buff argillaceous sandstone, kaolinitic and micaceous with fine angular quartz and some grit grains.
134′ – 162′	White kaolinitic sand and gravel with small blue-grey quartz pebbles about 10 mm.
162′ – 185′	Grey siltstone with a few grit size pebbles, coal fragments, mica, some pyrite. Lycopod megaspores.
185′ – 187′	Grey coarse quartz grit with abundant grit size grains, mostly subangular to angular and of grey quartz, opaline quartz, siderite.
187′ – 197′	Light buff coarse kaolinitic sandstone.
197′ – 250′	Grey siltstone with quartz-pyrite aggregates, subrounded to subangular quartz to grit size, broken quartzite pebble, coaly matter, biotite, felspar, siderite, pink garnet. Lycopod megaspores.
250′ – 300′	Grey silty mudstone with medium angular quartz chlorite, pink garnet, biotite, pyrite.
300′ – 400′	As above with plant fragments and pyrite aggregates to 5 mm.
400′ – 600′	Grey siltstone with abundant quartz-pyrite aggregates as above.
600′ –1100′	As above, with fine to medium angular quartz, pyrite.
1100′ –1295′	As above, with pyrite aggregates, quartzite.
1295′ –1474′	Grey calcareous siltstone with carbonaceous matter, very fine quartz grains in a calcareous matrix, fragments of quartzite, rounded quartz grains.
1474′ –1600′	Grey carbonaceous mudstone with coarse rounded quartz medium to fine angular quartz, carbonaceous siltstone.
1600′ –1625′	Dark grey calcareous and carbonaceous siltstone with very fine angular quartz, pyrite muscovite, biotite, coarse rounded to subrounded quartz, calcareous cement.
1625′ –1800′	Dark grey highly carbonaceous siltstone with fine mica and foraminifera at 1800′—*Hyperammina* sp., *Textularia* sp., ? *Polytaxis* sp., *Thurammina phialaeformis* Plummer.
1800′ –1900′	Dark grey carbonaceous siltstone with coarse subrounded quartz grains and foraminifera. The foraminifera are common but badly preserved, and identification for the most part would be hazardous. The assemblage includes cf. *Hippocrepinella biaperta* Crespin, *Hyperammina* cf. *acicula* (Parr) and *Thurammina phialaeformis* Plummer.
1900′ –1950′	Dark grey carbonaceous siltstone as above with calcareous patches and numerous badly preserved foraminifera.
1900′ –2000′	Brown sandy carbonaceous siltstone with fine muscovite, foraminifera *Hyperammina* sp., cf. *Hippocrepinella* sp., *Thurammina phialaeformis*.
2000′ –2088′	Dark grey glauconitic siltstone with fine to medium quartz grains, pyrite, pale green glauconite, some plant fragments. Abundant foraminifera including *Hyperammina acicula* (Parr), *Thurammina phialaeformis* Plummer, *Ammodiscus nonahensis* Crespin, cf. *Ammovertella inclusa* (Cushman and Waters), and species of *Ammobaculites*, (?) *Polytaxis*, *Trochammina*.

Stratigraphic Summary

25′ – 162′	"Jurassic"—(non-marine).
162′ –1800′	Lower Artinskian-Sakmarian (freshwater).
1800′ –2088′	Lower Sakmarian (marine).

Anna Creek

Drilled 1887 (Railway Bore)

Core Depth (feet)	
0′ – 18′	No samples.
18′ – 34′	Yellow micaceous siltstone with fine angular quartz, pink garnet, muscovite.
34′ – 400′	Dark grey very carbonaceous mudstone with abundant plant remains.
400′ – 500′	Very dark grey carbonaceous mudstone with abundant plant remains. Lycopod megaspores.

Core Depth (feet)	
500′ – 711′	Very dark grey laminated carbonaceous sandy siltstone with abundant plant remains. Lycopod megaspores. Moulds about 10 mm. long of (?) pelecypoda.
711′ – 802′	Grey calcareous and carbonaceous banded sandstone and siltstone with some glauconite, a soled pebble, unidentified spines and vertebrate teeth.
802′ – 825′	Dark grey laminated carbonaceous siltstone.
825′ – 988′	Hard dense pyritic and calcareous felspathic rock.
	Stratigraphic Summary
0′ – 711′	Lower Artinskian-Sakmarian (freshwater).
711′ – 825′	Lower Sakmarian (? marine).
825′ – 988′	Palaeozoic or Proterozoic.

Coorie Appa

Drilled 1895

Cuttings Depth (feet)	
0′ – 10′	Yellowish gritty clayey sand with angular to subangular quartz grains.
10′ – 20′	Cream fine to medium micaceous clayey sand with fine angular quartz grains, abundant muscovite, and carbonaceous matter.
20′ – 30′	Light grey kaolinitic sand with coarse quartz grains, muscovite, pyrite, grey quartz pebbles to 15 mm.
30′ – 50′	Light grey calcareous gritty clay with coarse grit pebbles of various kinds, mostly quartz but some porphyry, quartzite, pyrite. Fragment of a foraminifer.
50′ – 60′	Grey calcareous clay with mostly medium to coarse angular to subangular quartz, pyrite. Rare foraminifera *Hyperammina acicula*.
60′ – 70′	Grey calcareous clay, with unsorted quartz grains fine to coarse and mostly angular with fractured and pitted surfaces, abundant pyrite and felspar. *Hyperammina acicula* present.
70′ – 80′	Grey pebbly calcareous clay with small pebbles of various kinds—milky and grey quartz, felspar, limestone, pyrite.
80′ – 120′	Grey gritty calcareous clay with fine calcareous sandstone. *Hyperammina acicula* (1 fragment).
120′ – 130′	Grey gritty calcareous clay with abundant grey grit pebbles, mostly subangular felspar, quartzite, pyrite, calcareous sandstone. One specimen each of *Ammodiscus oonahensis* and *Hyperammina acicula*.
130′ – 146′	Grey gritty calcareous clay with grey quartz, subangular quartz grains, abundant calcareous sandstone fragments, pyrite. One broken *Hyperammina*.
146′ – 156′	Grey clay with sandstone pebbles 15 mm. long and smaller pebbles of diverse origin, pyrite, angular to rounded quartz grains, pink garnet.
156′ – 166′	Grey clay with small grit size pebbles of diverse origin, mostly angular grey quartz and grey limestone.
166′ – 196′	Grey clay with grit size grains, mostly grey quartz but some pink quartzite, granite, felspar, limestone, pyrite.
196′ – 216′	Grey calcareous gritty clay with abundant grit grains mostly angular to subangular grey quartz, felspar, pyrite, pink garnet. Foraminifera present—cf. *Lugtonia* sp., *Ammodiscus oonahensis*.
216′ – 236′	Grey pebbly clay with angular grey quartz pebbles, felspar.
236′ – 280′	Grey calcareous gritty clay with rounded to subrounded quartz to grit size.
280′ – 320′	Grey calcareous and pyritic clay with fine to medium and some coarse rounded to subrounded quartz, pyrite, pink garnet.
320′ – 428′	Grey calcareous and pyritic clay with pyrite quartz aggregates to 25 mm. long; calcareous sandstone, medium subangular quartz, pyrites, garnet, smoky and grey quartz.
428′ – 436′	Grey sand and clay with subrounded quartz grains, pyrite, biotite.
436′ – 503′	Grey pyritic sandy clay with medium subrounded quartz grains, abundant pyrite, garnet.
503′ – 528′	Light grey fine incoherent sandstone with some clay, subrounded to subangular quartz, garnet, chlorite, pyrite.

528' – 540'	Light grey conglomerate with medium quartz subrounded to rounded with pitted surfaces. Pebbles of various kinds to 50 mm.
540' – 573'	Buff medium quartz sand, fairly well sorted, with medium subangular to subrounded grains, garnet, pyrite.
573' – 660'	Fine light grey sand and sandy clay with fine angular quartz grains, pyrite, garnet. Calcareous sandstone boulder at 657-660 feet.
660' – 663'	Light grey calcareous sandy clay with medium angular to subrounded quartz, angular fine quartz, abundant pyrite cubes.
663' – 667' 8"	Light grey-buff medium quartz sand with subrounded grains and pebbles of quartzite and siliceous metasediment.
667' 8"– 674'	Light grey mudstone with fine angular to medium subangular quartz, pyrite, garnet.
674' " 692'	Grey irregularly laminated clay and fine sandstone.
692' – 768'	Light grey fine slightly clayey sand with garnet, pyrite and pebbles of various kinds to 60 mm.
768' – 792'	Blue-grey gravelly sandy siltsone with coarse grey quartz to gravel size, subrounded medium to coarse clear quartz, pyrite, garnet in a fine clay matrix.
794' –1036'	Grey grit in clayey matrix with pebbles to 25 mm. Pebbles of various kinds, granite, quartzite, limestone, pyrite.
1036' –1104'	Blue-grey shale—washings mainly light brown and grey fine mudstone, subangular and subrounded quartz, calcite, pyrite.
1104' –1858'	Chocolate calcareous shale with buff sand intercalations at 1464-1474, 1489-1497, 1840-1858 feet.

Stratigraphic Summary

0' – 30'	"Jurassic" (non-marine).
30' – 270'	Lower Sakmarian (marine).
270' –1104'	Lowermost Sakmarian (glacigenes).
1104' –1858'	Proterozoic (Marinoan).

Margaret Creek
Drilled 1897

Cuttings Depth (feet)	
0' – 2'	Red surface clayey soil.
2' – 8'	Yellowish gypseous clay.
8' – 13'	Brown lateritic ironstone and yellow weathered siltstone with mica, glauconite, fine angular quartz.
13' – 15'	Ferruginised calcareous siltstone.
15' – 38'	Grey flaky mudstone, with fine angular quartz grains, abundant muscovite, glauconite, plant remains, felspar. Rich in Aptian foraminifera, including *Haplophragmoides chapmani*, *Haplophragmoides dickinsoni*, *Ammobaculites* sp. 3 and associated arenaceous species.
38' – 51'	Fine white micaceous sand with fine angular quartz, muscovite, felspar, pyrite. A small foraminiferal fauna which may have been introduced from overlying strata during drilling.
51' – 128'	Grey brown sand with pebbles to 50 mm. white sandstone and buff arkosic sand.
128' – 149'	Arkosic grit and gravel.
149' – 168'	Dark blue grey flaky mudstone, with abundant pyrite, coarse rounded to subrounded clear quartz grains.
168' – 200'	Chocolate fine-grained mudstone (shale).
200' – 301'	Grey calcareous mudstone with calcite veins; blue grey clay, fine matrix with rounded quartz grains.
301' – 353'	Light grey-buff fine incoherent sandstone with medium subrounded to rounded well sorted quartz grains with pitted surfaces, pink garnet.
353' – 460'	Grey sandy clay (boulder clay) with abundant rounded quartz grains with etched surfaces, calcite, pyrite, slate, quartzite.
460' – 691' 3"	Light buff fine to medium incoherent quartz sand with angular to subrounded quartz grains, very little clay, pink garnet, pyrite. Calcareous at 555-560, 619-648 feet.

Stratigraphic Summary

0' – 38'	Aptian (marine).
38' – 149'	"Jurassic" (non-marine).
149' – 691' 3"	Lowermost Sakmarian (glacigenes).

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APPENDIX I.

Copy of Letter from J. W. Jones, Conservator of Water, to W. Howchin.

10th March, 1905.

W. Howchin, Esq.,
Lecturer in Geology,
The University of Adelaide.

Dear Sir,

You have always expressed your interest in the *Lake Phillipson Bore*, earlier samples from which I showed you and Professor Gregory some time ago.

The Boring is now practically completed with the result that it is bottomed in *Syenite* at about 3150 *feet*. The extremely hard rock has been penetrated 6 feet 6 inches and boring is going to 20 *feet* in the rock to satisfy the Govt. Geologist.

I send samples from 2028 ft. and 3124 ft. the latter showing small pieces of the syenite and indicating what might be expected a little deeper and what actually was found—the *bed rock* of syenite.

You will remember that I have always held that we have never had the *marine blue shale* of the Artesian Basin.

Faithfully yours,

JAMES W. JONES.

A NEW SPECIES AND SOME NEW RECORDS IN THE GENUS *CLOACJNA* (NEMATODA : STRONGYLOIDEA) FROM WESTERN AUSTRALIA

BY PATRICIA M. MAWSON

Summary

Cloacina setonicis sp. nov, is described from *Setonix brachyurus* from Rottnest Island, Western Australia. It differs from C. *bancroftorum* and *C. thetidis* in the presence of teeth in the oesophagus. Four species are recorded from *Macropus robustus* from near Marble Bar, namely: C. *communis, C. parva, C. hydriformis,* and *C. magnipapillata.* C. *magna* is considered *a* synomym of *C. communis.*

A NEW SPECIES AND SOME NEW RECORDS IN THE GENUS *CLOACINA* (NEMATODA: STRONGYLOIDEA) FROM WESTERN AUSTRALIA

by Patricia M. Mawson*

[Read 8 June 1961]

SUMMARY

Cloacina setonicis sp. nov. is described from *Setonix brachyurus* from Rottnest Island, Western Australia. It differs from *C. bancroftorum* and *C. thetidis* in the presence of teeth in the oesophagus. Four species are recorded from *Macropus robustus* from near Marble Bar, namely: *C. communis*, *C. parva*, *C. hydriformis*, and *C. magnipapillata*. *C. magna* is considered a synomym of *C. communis*.

INTRODUCTION AND ACKNOWLEDGMENTS

The nematodes recorded below were very kindly sent to the author by Dr. Shelley Barker of the Zoology Department of the University of Western Australia (from *Setonix brachyurus*) and Dr. E. H. M. Ealey then of the C.S.I.R.O. Wild Life Division (from *Macropus robustus*).

The four species of *Cloacina*, *C. communis*, *C. magnipapillata*, *C. hydriformis*, and *C. parva* which have been identified from *Macropus robustus*, have each been compared with para-type material in the Helminthological Collection of the Zoology Department of the University of Adelaide. They agree with the original descriptions, but in the first two listed, teeth have been observed in the oesophagus; in the other two these are absent. Discussion and description of these teeth is deferred to a separate study (Mawson, 1961, 84).

Cloacina setonicis, sp. nov.

(Figs. 1-5)

Host and Locality: *Setonix brachyurus*, Rottnest Island, Western Australia.

Short stout worms, tapering in oesophageal and tail regions. Males 3·5-4·2 mm. long, 350-400μ wide, females up to 7·7 mm. long, and to 600μ maximum breadth. Six lips and six elements of leaf crown distinct. Four submedian papillae small, each of two segments; lateral papillae very small. Buccal ring about 20μ long, 100μ diameter in male, 130μ in female, with symmetrically undulating anterior and posterior borders. Lumen of anterior end of oesophagus very wide in all specimens, with two circles each of three backwardly directed teeth, projecting from the wall of oesophagus into lumen. Nerve ring lies just anterior to mid-length of oesophagus, at same level as long thread-like cervical papillae; excretory pore just behind this.

Tail of female conical and sharply pointed, about 35μ long. Vulva 100μ in front of anus, and vagina about twice as long as tail. Eggs about 120μ by 80μ.

Spicules unusually long, 1/1·4-1/1·7 of body length, except in one specimen in which this proportion is 1/3. Gubernaculum heart-shaped, weakly developed. Bursa large, ventral lobes joined ventrally, dorsal lobe only slightly

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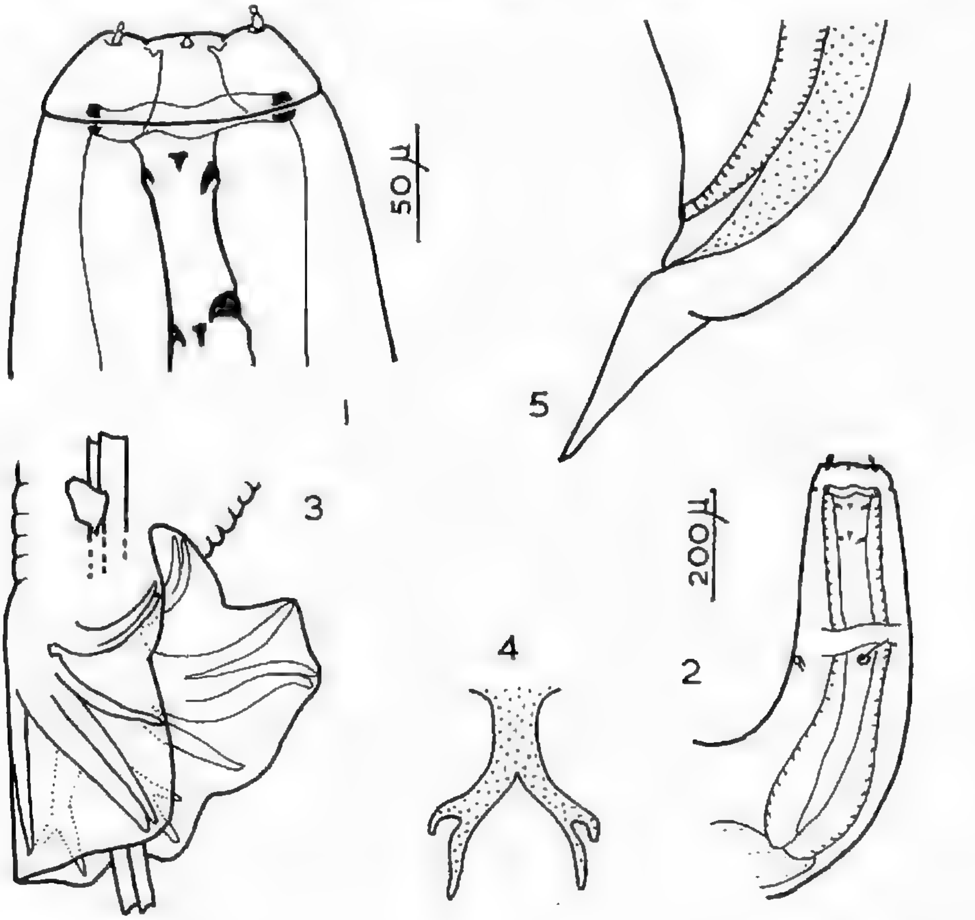
separated from laterals, and with only slight median indentation. Arrangement of rays shown in Figs. 3 and 4. Prebursal papillae present.

The new species closely resembles *C. bancroftorum* Johnston and Mawson (1939, 133) and *C. thetidis* Johnston and Mawson (1939, 532) in the shape of the oesophagus and the character of the head, but differs from them in spicule length and in the presence of teeth. The type specimens of these two species have been examined, and teeth do not appear to be present.



Cloacina parva Johnston and Mawson

Johnston and Mawson, 1938, 282. *Macropus robustus, Petrogale penicillata lateralis,* Central Australia.

Host and Locality: *Macropus robustus,* near Marble Bar, Western Australia.

The single male is 8·5 mm. long with oesophagus 1/13 and spicule 1/2·3 of body length; the six females are 6·8-11·8 mm. long, with oesophagus 1/13-1/16 of body length. No teeth were observed in the oesophagus.

Cloacina magnipapillata Johnston and Mawson

Johnston and Mawson, 1939, 540. *Macropus major, M. rufus,* New South Wales.
Johnston and Mawson, 1939, 307. *M. major,* Victoria.

Host and Locality: *Macropus robustus,* near Marble Bar, Western Australia.

About thirty worms are present. Males measure 5·9-8·3 mm. in length; oesophagus 1/7·5-1/13, and spicules 1/2-1/2·6 of body length. Females are

6·0-12·8 mm. long, with oesophagus 1/10-1/16 of body length. There is a slight enlargement of the oesophagus just in front of the nerve ring, and three teeth project into the lumen in this region. These structures will be described later (Mawson, 1961, 88).

Cloacina communis Johnston and Mawson

Syn. *Cloacina magna* Johnston and Mawson.
Johnston and Mawson, 1938, 275, 277. *Macropus robustus*, Central Australia.
Johnston and Mawson, 1939, 133. *Protemnodon parryi* (s. *Macropus parryi*), Queensland.
Johnston and Mawson, 1940, 97. *M. major melanops*, *Petrogale xanthopus*, South Australia.
Johnston and Mawson, 1940, 468. *M. major*, New South Wales.

Host and Locality: *Macropus robustus*, near Marble Bar, Western Australia.

This species is easily recognised because of the large size and distinctive shape, both of the whole body, especially the female, and of the oesophagus. *C. magna* Johnston and Mawson was described from the same host and from the same locality as the type of *C. communis*. It is now thought after comparison of the original material, that the very slight differences observed between the species are insignificant, and only one species is concerned. *C. communis* has page priority. Three females are present in the new material. They are 38-40 mm. long, the oesophagus 1/14·0-1/14·3 of the body length. Teeth are present in both paratype and fresh material, lying in three groups one behind the other where the oesophagus widens towards the basal bulb. These will be more fully described later.

Cloacina hydriformis Johnston and Mawson

Johnston and Mawson, 1938, 273. *Petrogale penicillata lateralis*, Central Australia.
Johnston and Mawson, 1940, 97. *Macropus major melanops*, South Australia.

Host and Locality: *Macropus robustus*, near Marble Bar, Western Australia.

Cloacina hydriformis may be recognised by the large outstanding submedian cephalic papillae, and by the shape of the buccal ring, which is thin-walled with out-turned anterior margin. Only females are present in this collection. They agree with the original description, and no teeth have been observed in the fresh material. They are rather longer than the type specimens, 7·0-7·5 mm., with oesophagus 1/16·2-1/18·7 of the body length.

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A NOTE ON THE OCCURRENCE OF OESOPHAGEAL TEETH IN SPECIES OF THE GENUS CLOACINA (NEMATODA: STRONGYLOIDEA)

BY PATRICIA M. MAWSON

Summary

It has been found that in some species of Cloacina teeth project from the lining of the oesophagus into the lumen. Each tooth lies in the mid-line of a sector of the oesophagus. In each species the number, arrangement and position of the teeth is constant. There is no evidence that they serve as outlets for oesophageal glands.

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by PATRICIA M. MAWSON*

[Read 8 June 1961]

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It has been found that in some species of *Cloacina* teeth project from the lining of the oesophagus into the lumen. Each tooth lies in the mid-line of a sector of the oesophagus. In each species the number, arrangement and position of the teeth is constant. There is no evidence that they serve as outlets for oesophageal glands.

INTRODUCTION AND METHODS

In a recent study of the nematodes from the Western Australian wallaby, *Setonix brachyurus*, a new species, *Cloacina setonicis*, was identified and described (Mawson, 1961). In this species teeth were noted projecting into the lumen of the oesophagus near its anterior end. Such teeth do not appear to have been described from other Trichoneminae, nor, indeed, from any other nematode, other than at the anterior end projecting into the buccal cavity. The question arises, are they present, but unobserved, in other species of the same genus? Preliminary investigations into this possibility have shown that teeth are present in some species, not in others. Examination has been made of the paratypes of some *Cloacina* spp. and of some freshly obtained *Cloacina* spp., as well as of some species of related genera.

If teeth be present they can be seen in an entire mount of a fresh specimen cleared in lactophenol. In specimens which have been preserved for a long time and are dark, it is necessary to clear with gum chloral or Berlese's fluid (both of which are excellent media for showing cuticular structures) and sometimes to make a separate mount of the oesophagus. In any case, this last was done wherever possible, as the teeth may be seen much more distinctly. To find the relation of the teeth to the wall and lumen of the oesophagus, sections were made, mostly transverse sections in series. Some were made from paraffin embedded specimens using a microtome, others with a fine knife under the dissecting microscope. These latter had the advantage that it was possible to make the cut at the angle and in the position desired, which, with curved worms, is almost impossible with the microtome. The hand-cut sections were made about 30-40μ thick, and were mounted in Berlese's fluid. Though some of the material was stained with Delafield's haematoxylin no attempt has been made at any real study of the histology. The oesophagus of some of the freshly obtained specimens was left for about 12 hours in 10 p.c. potassium hydroxide solution, so that all but the chitinous lining was destroyed, leaving the teeth (if present) very clearly visible.

DESCRIPTION OF TEETH

In many *Cloacina* species, if not in all, the lining of the oesophagus appears in whole mounts to be uneven. In section this is seen to be due to the undulating nature of the radial arms of the lumen, rather than to any particular thick-

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ening of the lining. This uneven appearance is seen also in other strongyles; it has been described, for example, by Immink (1924) for *Strongylus edentatus*. In the Australian genera *Zoniolaimus* and *Pharyngostrongylus* the lining usually does not give this appearance. The structures which are now identified as teeth in *Cloacina* spp. are very much more definite than these projections and cannot possibly be mistaken for them. The teeth occur only in some species and in these they are arranged in a characteristic way and in a constant position in the oesophagus. Even in the few species so far examined it is clear that the presence and arrangement of the teeth are a feature of value in identification of the species.

The structure of the oesophagus of *Cloacina* spp. is very similar to that of other strongyles in which it has been described, but there are differences in the position and number of the longitudinal thickenings on the lining of each section. Typically, in the anterior part the lumen is wide with pinched angles, and the lining of more or less even thickness. Further back the lumen is relatively smaller and more tri-radiate, and the lining develops the longitudinal rods or thickenings, apparently formed by fusion of a rod from each of adjacent sectors. The longitudinal canal seen in some nematodes at the outer end of each radius of the lumen has not been seen in any of the *Cloacina* spp. examined.

In species in which a tooth is present, the tooth projects into an enlargement of the lumen which is sometimes reflected in a slight swelling of the whole oesophagus. The tooth is the shape of a rose thorn, projecting either forward, or, more rarely, backward, into the lumen. Each tooth is formed in the midline of the sector involved from the greatly thickened cuticular lining, the projecting point balanced in case of large teeth by an extension of the thickening into the oesophageal tissue.

It is not clear whether the tooth is of functional importance. There does not appear to be any outlet through it for glandular secretion, certainly no duct has been found similar to that in *Ancylostoma* spp. There is no evidence that the teeth are movable; they are always at the same angle in different specimens of a species. They might help in some way to regulate the flow of oesophageal contents, but their appearance does not suggest that they would form efficient valves. If their action is merely abrasive, the presence of a point is unexplained.

From the few species so far studied, it appears that teeth may occur in one of three regions of the oesophagus, and that in each region the character of the tooth is slightly different.

1. At the anterior end, close to the mouth, e.g. *C. setonicis*. In this species the teeth are small.
2. Just in front of the nerve ring, e.g. *C. magnipapillata*, *C. macropodis*, *C. longispiculata*. In these the teeth are of medium to large size and the roots not pronounced; the oesophagus is swollen in the region of the teeth.
3. Well behind the nerve ring, just in front of the terminal oesophageal swelling, e.g. *C. communis*, *C.* sp. inq. In these the teeth are larger, more numerous, and with well developed basal processes; the oesophagus is swollen in the region of the teeth.

SPECIES IN WHICH TEETH ARE NOT PRESENT

Both fresh material and paratype specimens have been examined of *C. hydriformis* Johnston and Mawson 1938, and *C. parva* Johnston and Mawson 1939, and no teeth have been observed. They appear to be absent also in the paratype specimens of *C. bancroftorum* Johnston and Mawson 1939, and *C. thetidis* Johnston and Mawson 1939, and although these are long-preserved

specimens, they are in such good condition that it is thought that, if present, they would be seen. Some other species which have been examined but in which teeth are apparently absent, are *Pharyngostrongylus alpha* J. and M. 1938,

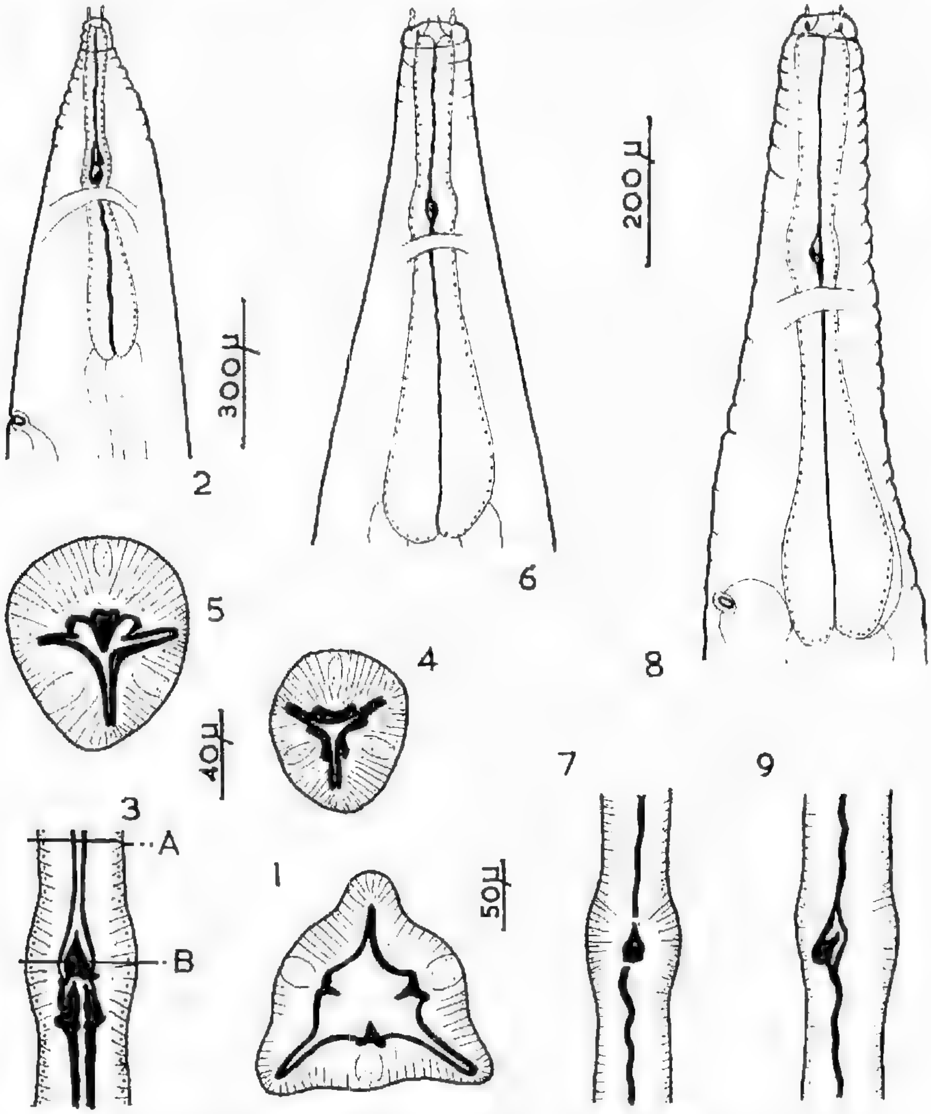


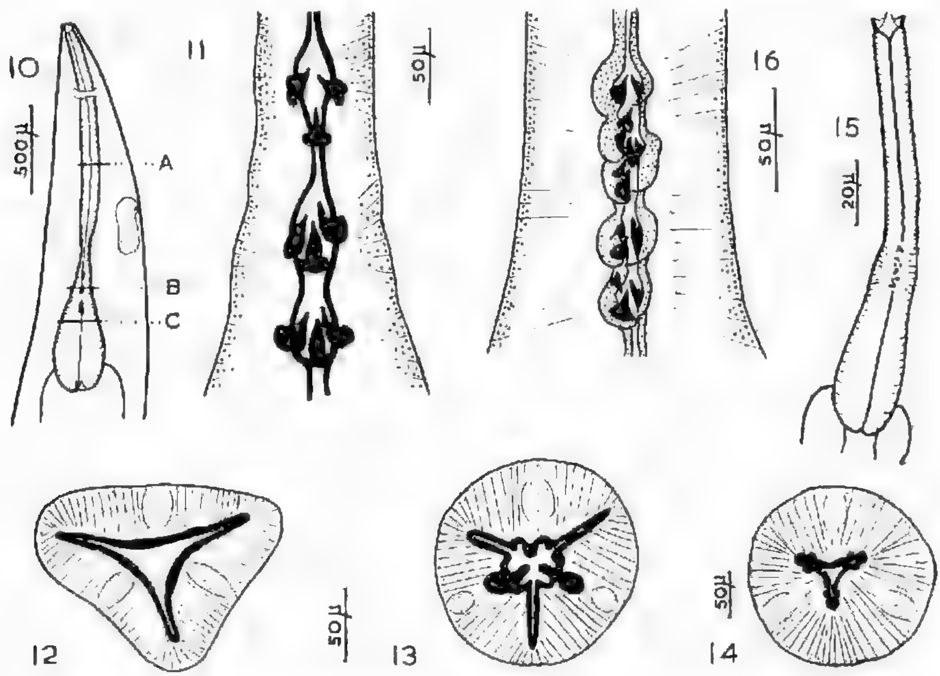
Fig. 1. *Cloacina setonicis,* T.S. of oesophagus near anterior end. Figs. 2-5. *C. magnipapillata.* 2, anterior end of body; 3, oesophagus in region of preneural bulge; 4 and 5, sections of oesophagus at levels indicated on Fig. 3 by lines A and B respectively. Figs. 6-7. *C. longispiculata.* 6, anterior end of body; 7, oesophagus in region of preneural bulge. Figs. 8-9. *C. macropodis.* 8, anterior end of body; 9, oesophagus in region of preneural bulge. Figs. 3, 4 and 5 to same scale; Figs. 1, 7 and 9 to same scale.

P. beta J. and M. 1938, *Labiostrongylus longispiculata* Wood 1929, *L. eugenii* J. and M. 1940, and *Trichonema* spp. from a local horse, all of which were studied as fresh material, and *Quilonia* sp., long preserved, from a zoo elephant.

SPECIES IN WHICH TEETH HAVE BEEN FOUND

Cloacina setonicis Mawson (1961, 81) (Fig. 1)

Type material was examined when newly preserved. Six small, backwardly directed teeth are present, arranged in two circles each of three teeth, the most anterior just behind the buccal capsule, the second a short distance behind this. Profile views of teeth in the oesophagus are given in Figs. 1 and 2 of the original description.



Figs. 10-14. *Cloacina communis*. 10, anterior end; 11, pre-bulbar region of oesophagus; 12, 13 and 14, transverse sections through oesophagus at levels shown on Fig. 10 by lines at A, B and C respectively. Figs. 12 and 13 to same scale. Figs. 15-16, *Cloacina* sp. inq. 15, oesophagus; 16, prebulbar region of oesophagus.

Cloacina magnipapillata Johnston and Mawson (1939, 530) (Figs. 2-5)

Fresh material belonging to this species has now been obtained from *Macropus robustus* from Western Australia. About thirty worms have been examined and teeth are clearly present in all, in exactly similar position and arrangement in all specimens. They lie in a slight swelling of the oesophagus just in front of the nerve ring. There are three teeth, the larger of which comes from the dorsal sector of the oesophagus and lies just in front of the other two, which are subventral.

Paratype specimens of this species have also been examined. They are very dark with age. Teeth are not distinct, but there is a suggestive swelling of the outline of the oesophagus in front of the nerve ring, and an interruption of the central line of the oesophagus in this region.

Cloacina longispiculata Johnston and Mawson (1939, 131) (Figs. 6-7)

Paratype material has been examined, but no fresh material is available. When cleared in Berlese's fluid, there appears to be a single small tooth lying just anterior to the nerve ring in a slight swelling of the oesophagus.

Cloacina macropodis Johnston and Mawson (1939, 278) (Figs. 8-9)

No fresh material is available of this species. In paratype specimens a tooth is clearly present, lying just anterior to the nerve ring. The appearance of the oesophagus in this species is very similar to that of *C. longispiculata*, but the species may be distinguished by the shape and size of the sub-median cephalic papillae, and by the very long spicules in *C. longispiculata*.

Cloacina communis Johnston and Mawson (1938, 275) (Figs. 10-14)

Fresh and paratype specimens have been examined and teeth are distinct in cleared specimens. There are three successive groups of three teeth each, the hindermost group lying where the oesophagus widens towards the terminal bulb; at the level of each group the oesophagus is slightly wider. The teeth are large with well-developed basal thickenings.

Cloacina sp. inq. (Figs. 15-16)

Some worms belonging to a species resembling *C. frequens* and *C. ernabella* have been found in *Macropus robustus* from Marble Bar in Western Australia. As only females are present, the species cannot be identified. The dentition in these is, however, so distinctive that a figure has been included here. There are about fifteen teeth lying where the oesophagus begins to widen posteriorly. They are arranged in roughly five groups closely succeeding one another. The teeth are mostly large with well-developed basal structures, and point forward, but at least two are small.

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SCLEROPHYLL COMMUNITIES IN THE INGLEWOOD DISTRICT, MOUNT LOFTY RANGES, SOUTH AUSTRALIA THEIR DISTRIBUTION IN RELATION TO MICRO-ENVIRONMENT

BY HELENE A. MARTIN

Summary

A study of a dry sclerophyll forest has been undertaken with the object of relating minor variations in the plant communities to certain environmental factors. Five communities were recognised and these were classified as three plant types and two associations. The species of *Eucalyptus* concerned were *E. obliqua*, E. *elaeophora* and *E. fasciculosa.* The environmental factors investigated included rainfall, insolation, soil profile, soil fertility and soil moisture. The range of variation both in the vegetation and in the environment was relatively small and, in fact, both presented graded series rather than discontinuities. It proved difficult to establish any significant correlations. However, one community, the E. *obliquu-E. elaeophora* type, was observed to possess the highest rate of evapotranspiration and a second community, E. *elaeophora* type was associated with soils of relatively high fertility.

SCLEROPHYLL COMMUNITIES IN THE INGLEWOOD DISTRICT, MOUNT LOFTY RANGES, SOUTH AUSTRALIA THEIR DISTRIBUTION IN RELATION TO MICRO-ENVIRONMENT

HELENE A. MARTIN[1]

[Read 8 June 1961]

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INTRODUCTION

The dry sclerophyll forest near Adelaide covers an extensive region and exhibits many variations both in the dominant upper stratum and understory. An earlier comprehensive study by Adamson and Osborn (1924) recognised four main communities within the Stringybark Forest, viz. forests on quartzitic soils, forests on ironstone soils, gully forests and "box" forests. Within these four forest communities there were smaller changes associated with habitat differences, particularly in the understory. For example, within the forests on quartzitic soils (*Eucalyptus obliqua* dominant) three such changes were noted, in (1) communities on lower hills and open slopes, (2) communities on southern protected slopes and high plateaux, and (3) communities on steep rocky slopes. Each contained some species characteristic of the particular habitat. Within the "box" (*E. elaeophora*) forests, two facies occurred in the undergrowth, one of Epacrids and Hakeas and the other with *Lepidosperma semiteres* abundant (Adamson and Osborn, 1924). Later workers, Specht and Perry (1948), made an extensive study of part of the Mount Lofty Ranges, concentrating on the distribution of dominant trees. They discussed formations and their distribution in relation to environment and noted that the undershrubs varied with every micro-habitat, independently of the dominant trees. The understory was not studied in great detail, but the authors pointed out the need for "further investigation . . . of the individual species of the lower stratum".

At Breakneck Hill, Inglewood (about 16 miles N.E. of Adelaide), there is a complex patchy distribution of many species frequent in the dry sclerophyll forest formation of the Adelaide Hills. The various communities present are characteristic of major variations noted in this formation by the previous workers

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(loc. cit.). Consequently, this particular locality was studied with the hope of finding some explanation for the observed distributions.

The area selected for study is approximately one mile square and situated on a broad north-south ridge. With an elevation of 1,000 to 1,400 feet, the ridges are comparatively flat-topped with steeply sloping sides. The small streams dissecting the region form the upper reaches of tributaries to the Little Para River. Fig. 1 shows the general location of the area and the topography can be seen in Fig. 15.

THE VEGETATION

The dominant tree species are the mesophanerophytes, *Eucalyptus obliqua*,* *E. elaeophora* and *E. fasciculosa*. Most of the trees are regrowths from old stumps (see Plate 1A) since woodcutters periodically work in the district. An

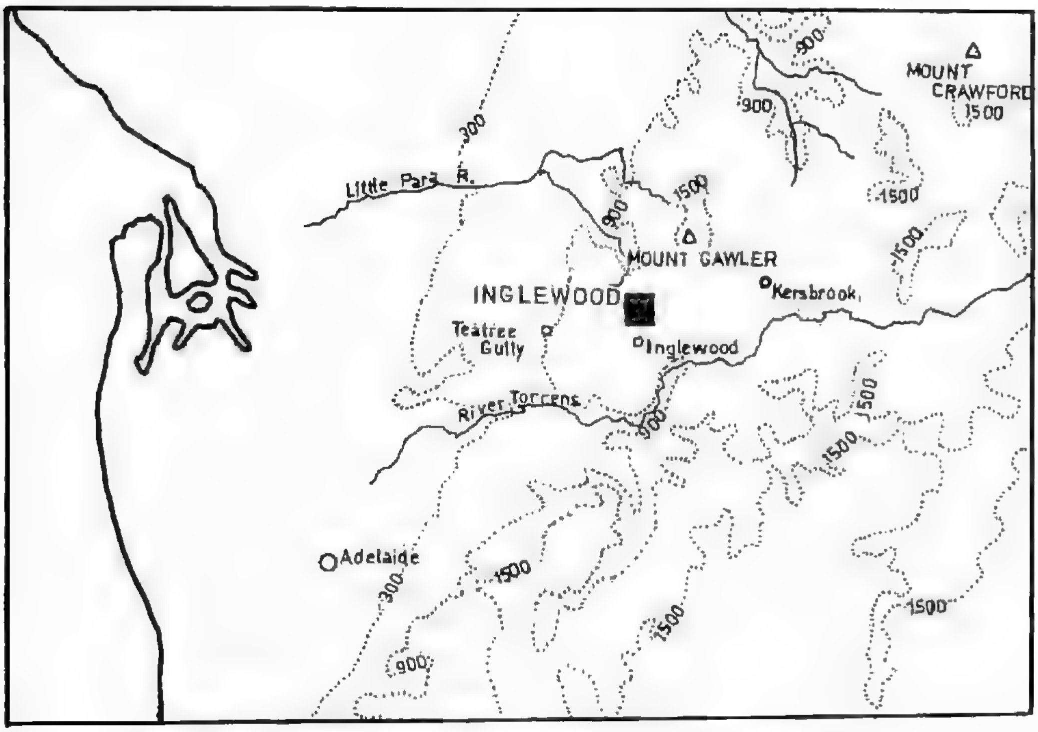

Fig. 1. Map showing the location of the area studied.

occasional old tree or burnt-out shell indicates trees of quite large dimensions, three or four feet in diameter. Today, the majority are only about a foot in diameter and 12 to 20 feet high. This agrees with the findings of Webb (1952). The average density is about 400 trees per acre (8 trees per plot of 10 yards square) and the structure is that of an open, low-growing forest. This stunted appearance is accentuated by the nature of *E. elaeophora* itself which can either occur as a large tree or develop a "mallee-like" habit (Adamson and Osborn, 1924), the latter more often on rocky ridges (Wood, 1937).

* The identification and nomenclature follows Black (1943-57). A collection of specimens has been lodged with the State Herbarium of South Australia, Botanic Garden, Adelaide.

Beneath the trees, there is a layer of sclerophyllous shrubs, nanophanerophytes, up to four feet in height and composed of *Xanthorrhoea semiplana*, *Hakea rostrata*, *Leptospermum myrsinoides* and occasionally *Casuarina muelleriana* and *Pultenaea daphnoides*. Sometimes these shrubs grow so closely and densely that they form an almost impenetrable thicket, but usually the individual bushes are more scattered and discrete and in some localised spots, almost absent (see Plate 3B).

The third stratum, the ground layer, consists of low sprawling sclerophyllous shrubs, chamaephytes, various geophytes and hemicryptophytes. The chief ones

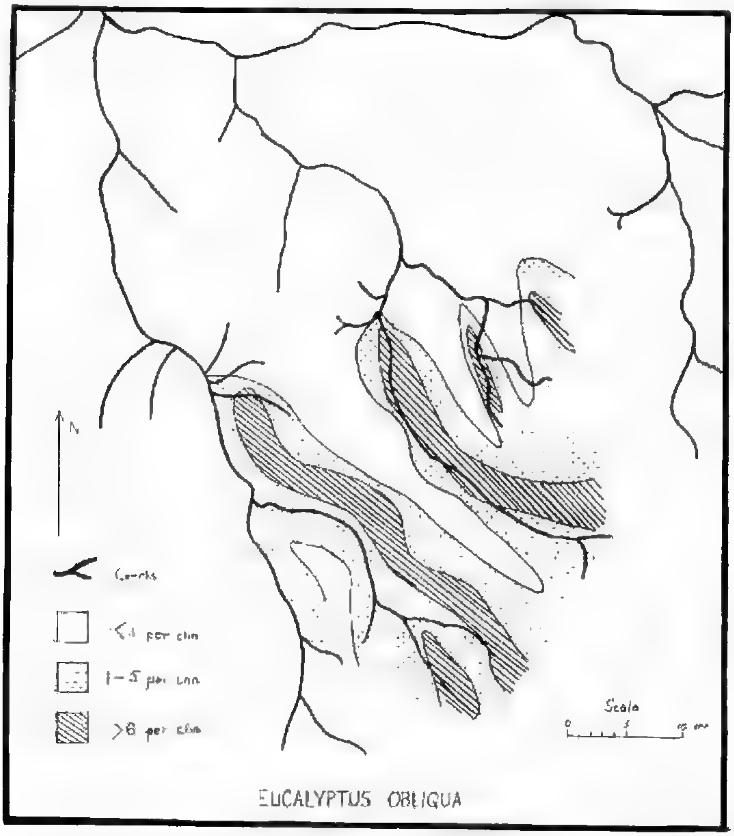

Fig. 2. *Eucalyptus obliqua*. This species is restricted to the southern part, on higher elevations, southern aspects and valleys.

are *Hibbertia acicularis*, *H. sericea*, *Acrotriche serrulata*, *Platylobium obtusangulum*, *Lepidosperma semiteres* (see Plate 2A) and *Lomandra fibrata*. The last-named species forms a low, continuous grass-like cover, 4 to 6 inches high (see Plate 1B). True grasses, however, are not common, in keeping with most sclerophyllous communities (Wood, 1937).

Of the various ways possible to obtain quantitative data (Goodall, 1952), the following method was adopted for sampling and recording. Line transects were run at five-chain intervals along the ridge, and orientated perpendicular to its length so that they ran up hill and down again. The number of species

brushing the legs in every chain was counted. This gave a series of quadrats one foot to one foot six inches in width and 22 yards long. It was felt that this particular method was most suited to the problem, in that it would reveal the nature and range of variation and yield the most information for the labour involved.

The number of each species per quadrat was then mapped and lines drawn enclosing areas of equal density. This method is similar to that used by Il'insky and Posil'skaya in 1929, who drew "isolines" connecting points at which the frequency of a given species was the same (Goodall, 1952). Pidgeon and Ashby

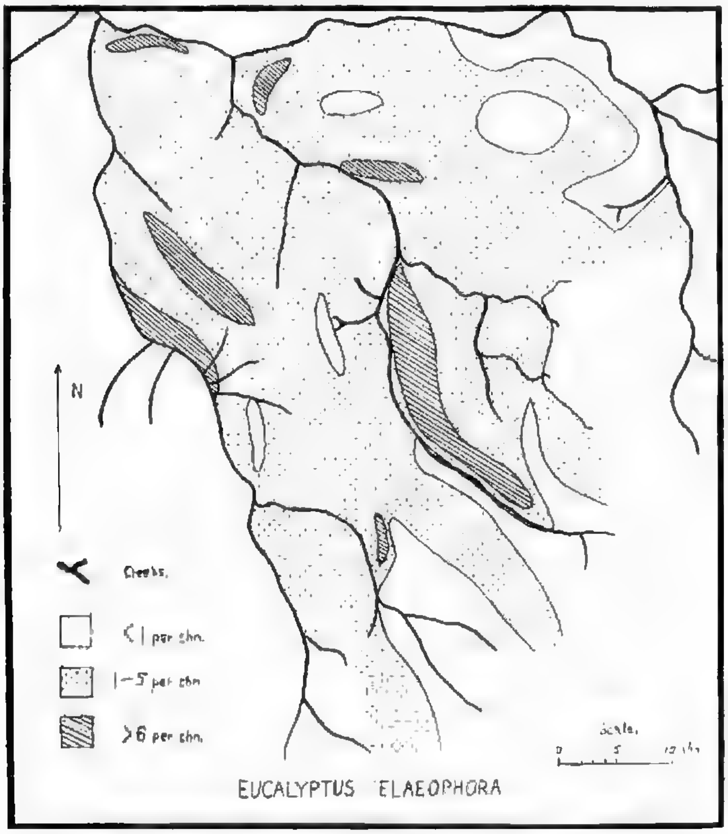

Fig. 3. *Eucalyptus elaeophora*. Distribution is widespread and fairly uniform. It tends to be absent from the southern parts where *E. obliqua* is common and along the narrow creek flats where *E. camaldulensis* is dominant.

(1942) constructed isonome maps in which lines joined points of equal percentage frequencies, based on the total number of plants present. This percentage basis enabled the maps to be superimposed, and at any given point, the total of all species was 100 per cent. The isoline maps constructed for Inglewood are based on actual numbers since the main interest was the distribution of the individual species and their correlation with environment.

For the densities and distribution of the major species, see Figs. 2 to 12 inclusive. The only important species not represented here is *Lomandra fibrata* which was not recognised or recorded in the earlier part of the work.

THE COMMUNITIES

The detailed examination of the distributions of numerous species is rather unwieldy. To facilitate the use of such data, they need to be simplified by some method of classification. The devices which have been used to classify and the resultant plant societies are legion (Braun-Blanquet, 1951) and the merits of each have been much contested. Indeed, it often seems that classification is an end in itself.

The most noteworthy attempt at an objective approach is that of Goodall. In his paper, "The Use of Positive Interspecific Correlation" (Goodall, 1953), he

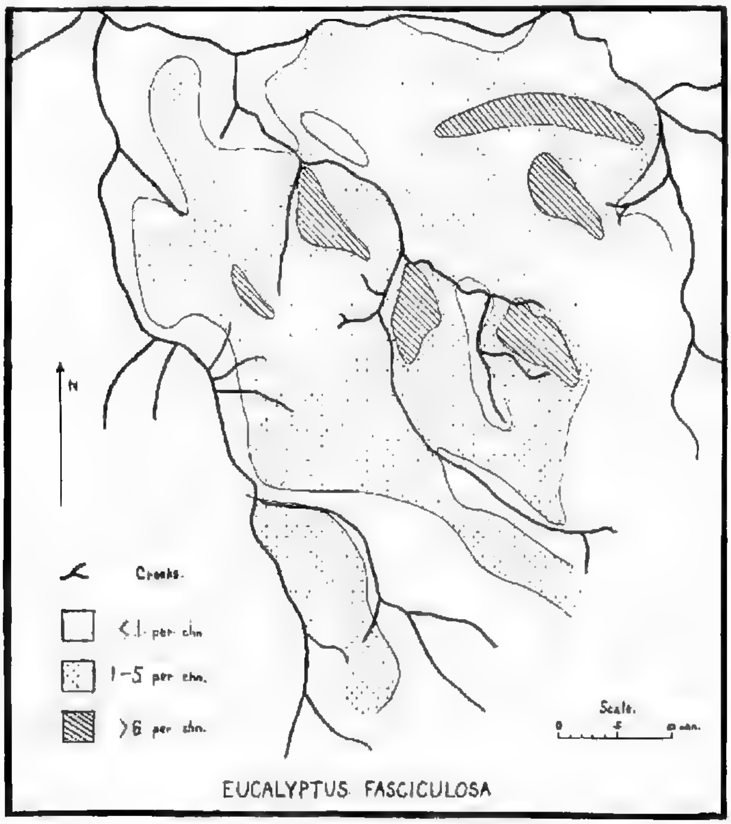

Fig. 4. *Eucalyptus fasciculosa* is widespread and uniform in distribution. It tends to be absent where *E. obliqua* and *E. camaldulensis* are dominant.

regards vegetation as being heterogeneous, the cause of which is usually habitat variation. If the distribution of one species is influenced by environmental differences, it is highly likely that others will be similarly affected, depending on their tolerances. If two species are common in the same quadrats, then they will be positively correlated. If one species avoids the habitats where another grows, then they are negatively correlated. Whether two species can be correlated is tested statistically by preparing a 2×2 table and comparing observed occurrences with those expected on a random basis. A χ^2 test is applied, at an arbitrary level of significance.

The 381 quadrats recorded were sorted into five homogeneous groups using the method of positive interspecific correlation described by Goodall (1953). The level of significance chosen was P = 0·1 p.c. ($\chi^2 = 10{\cdot}827$), since a preliminary trial using P = 1·0 p.c. ($\chi^2 = 6{\cdot}635$) as employed by Goodall on the Victorian Mallee gave seventeen communities thus defeating the aim to produce a workable system of classification (Martin, 1960). The reason for this difference was the large number of common species, often 10-12, which were present within each quadrat. Thus the possible number of paired species was large and interspecific correlations were high.

TABLE 1

Frequency of the *Species (%)

Species	Community Number				
	I (107)†	II (82)	III (75)	IV (75)	V (42)
Eucalyptus obliqua	69·1	24·4	16·0	14·7	7·1
E. elaeophora	62·6	100·0	100·0	64·0	100·0
E. fasciculosa	27·1	100·0	100·0	78·7	45·2
Xanthorrhoea semiplana	34·6	16·3	56·0	37·4	23·8
Hakea rostrata	29·9	65·9	100·0	52·0	28·6
Casuarina muelleriana	18·7	23·2	49·3	38·7	26·2
Leptospermum myrsinoides	49·5	75·6	100·0	56·0	38·2
Hibbertia acicularis	94·4	100·0	100·0	100·0	19·0
H. sericea	52·3	97·6	100·0	77·3	100·0
Platylobium obtusangulum	80·4	51·2	42·7	20·0	2·4
Lissanthe strigosa	16·8	14·6	16·0	17·4	23·8
Leucopogon virgatus	28·0	41·4	32·0	16·0	19·0
Acrotriche serrulata	58·0	85·3	64·0	54·6	33·3
Astroloma humifusum	45·8	59·7	52·0	54·6	66·7
Lepidosperma semiteres	93·5	96·3	96·0	100·0	33·3
Dillwynia hispida	46·7	46·4	36·0	12·0	16·6
Tetratheca pilosa	40·2	50·0	36·0	14·7	9·5
Pimelea spathulata	31·8	100·0	18·7	20·0	21·4
Grevillea lavandulacea	8·6	3·7	—	—	—
Spyridium parvifolium	13·1	9·7	16·0	12·0	2·4
Acacia pycnantha	21·5	31·7	9·3	32·0	52·3
A. myrtifolia	17·8	8·5	4·0	4·0	2·4
A. obliqua	1·9	13·4	12·0	13·3	—
Pultenaea daphnoides	59·0	24·4	10·7	20·0	4·8
P. largiflorens	27·1	53·7	46·6	37·4	21·4
Daviesia corymbosa	14·0	1·2	1·3	1·3	—
Lomandra fibrata	abundant	present	present	present	rare

* The common, important species. There are 20 to 30 less common species.
† Number of quadrats examined in each community.

Tables 1 and 2 list respectively the frequencies and average densities of the species and Fig. 13 shows the distribution of the groups.

On examination of the species lists, it can be seen that Community I stands out from the others in that it has relatively high frequencies of *Eucalyptus obliqua*, *Platylobium obtusangulum* and *Pultenaea daphnoides* with low values for the larger shrubs (*Xanthorrhoea semiplana*, *Hakea rostrata*, *Casuarina muelleriana*, *Leptospermum myrsinoides*). (See Plate I A and B.) Community V is also notable in that most species are poorly represented, the only high frequencies being *E. elaeophora* and to a lesser extent, *Astroloma humifusum* and *Acacia pycnantha* (see Plate 3B). The remaining three Communities, II, III and IV (see

Plates 2 A and B, 3A), are not as well defined and only a few species show any marked differences, e.g. *Pimelea spathulata*: II, 100 p.c., III 18·7 p.c., IV 20 p.c. Thus it seems that these three are more closely related to each other, and this is further shown when mapping the distribution of the communities. Communities I and V form relatively pure areas with few "strays" of the other communities. But this is not so with Communities II, III and IV, which present such an admixture that it is difficult to determine the majority (see Fig. 13). For this

TABLE 2

Mean Density (per chain quadrat)

Species	Community Number I (107)†	II (82)	III (75)	IV (75)	V (42)
Eucalyptus obliqua	4·1	1·2	0·3	0·6	0·5
E. elaeophora	1·8	3·5	2·5	1·9	3·3
E. fasciculosa	0·8	3·1	3·5	2·7	1·3
Xanthorrhoea semiplana	1·9	5·2	5·9	5·4	2·5
Hakea rostrata	1·2	2·7	5·6	2·8	1·0
Casuarina muelleriana	0·7	0·7	1·0	1·8	0·9
Leptospermum myrsinoides	4·0	10·4	13·8	5·5	4·3
Hibbertia acicularis	14·4	12·6	12·6	13·9	2·5
H. sericea	5·3	11·3	12·0	7·9	13·5
Platylobium obtusangulum	7·0	2·5	1·6	0·9	—
Lissanthe strigosa	0·7	0·9	1·0	0·8	2·4
Leucopogon virgatus	0·7	1·3	0·5	0·4	0·6
Acrotriche serrulata	1·3	1·4	1·7	1·2	0·6
Astroloma humifusum	1·0	1·8	1·3	1·6	1·1
Lepidosperma semiteres	16·5	14·4	12·1	13·8	4·1
Dillwynia hispida	1·6	1·3	0·9	0·4	0·7
Tetratheca pilosa	0·9	1·2	0·7	0·2	0·2
Pimelea spathulata	1·0	2·7	0·5	0·4	0·6
Grevillea lavandulacea	0·2	—	—	—	—
Spyridium parvifolium	0·7	0·7	1·2	0·4	—
*Acacia pycnantha**	0·7	1·0	0·2	1·3	1·4
Acacia myrtifolia	1·2	0·2	—	0·1	—
A. obliqua	—	0·5	0·3	0·6	—
Pultenaea daphnoides	3·3	1·3	0·3	0·6	0·1
P. largiflorens	2·6	2·4	2·5	3·5	1·9
Daviesia corymbosa	0·3	—	—	0·1	—
Lomandra fibrata	abundant	present	present	present	rare

* There has been recent "wattle stripping", so these figures are probably too low.
† Number of quadrats examined in each community.

reason, the boundaries between these three related communities are drawn as broken lines and could be considered as subgroups of a larger more diverse grouping. However, the classification of these communities will be discussed in detail later.

It can be seen from the frequencies and densities (Tables 1 and 2) that no species is confined to any one or two communities. The difference is rather that one species is relatively abundant or relatively scarce from one community to the other. The communities are arranged approximately in the order in which they occur on the map from north to south or following the frequencies of *Eucalyptus obliqua*.

Community I	Frequency of *E. obliqua* = 69·1 p.c.
Community II	Frequency of *E. obliqua* = 24·4 p.c.
Community III	Frequency of *E. obliqua* = 16·0 p.c.
Community IV	Frequency of *E. obliqua* = 14·7 p.c.
Community V	Frequency of *E. obliqua* = 7·1 p.c.

Fig. 14 shows the density of each species plotted against the communities in this order and it can be seen that the continuum (Curtis and McIntosh, 1951, and Whittaker, 1951) exists through the communities.

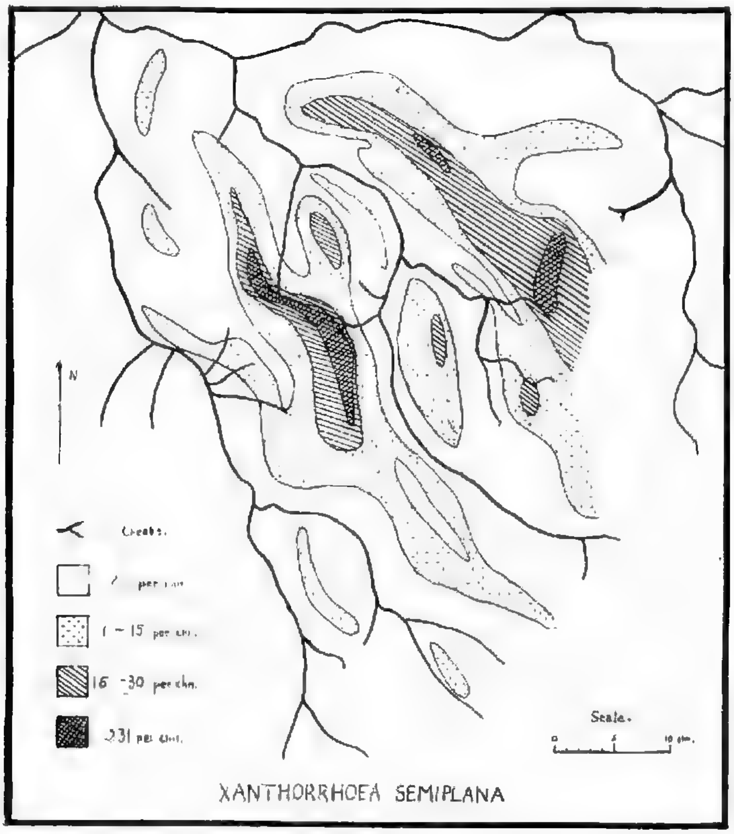

Fig. 5. *Xanthorrhoea semiplana*. This species is rarely found in valleys and reaches its maximum density on the ridge tops.

CLASSIFICATION

In an attempt to classify these five communities, the concepts set out by Beadle and Costin (1952) have been followed. These authors stress that vegetation should be classified on its inherent characteristics, not on aspects of environment. The fundamental unit, an association, is defined by these authors as a climax community with a qualitatively uniform upper stratum, floristically and structurally. Related associations are grouped into an alliance which takes its name from the most common species. Alliances are further grouped into formations. The problem of ecotonal regions, as encountered by Specht and Perry (1948) is overcome by elevating these communities to unit status.

However, *Eucalyptus* species are extremely sensitive to small environmental changes. This means that a small, local change in a habitat factor could cause a change in one or more eucalypt, with little change in any other species. By Beadle and Costin's definition, this small local change becomes a different association. Consequently one obtains innumerable small associations over a relatively small area, rather like Ostvald (1923) who described 164 associations over 40 square miles (cited by Crocker and Wood, 1947). On the other hand, Tansley and Chipp (1926) define an association as "the largest unit which consists of a definite assemblage of species (usually with definite dominants)

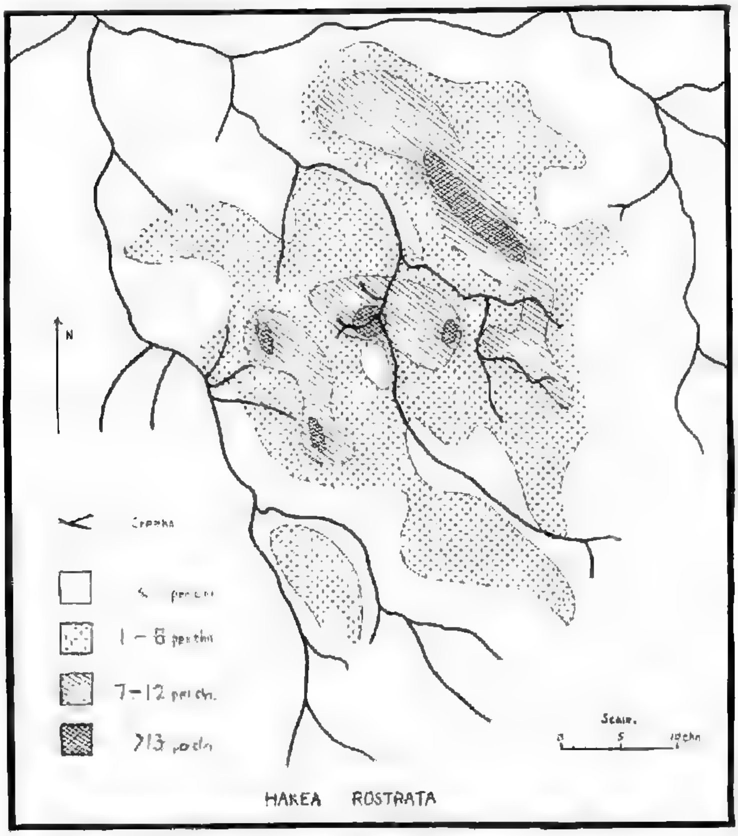

Fig. 6. *Hakea rostrata*. Distribution roughly coincides with that of *Xanthorrhoea semiplana*, but maximum densities are not necessarily the same. *Hakea rostrata* is present in some valleys.

and a definite habitat". We in Adelaide feel that an association should be reasonably broad to be of any value, otherwise "association" might just as well be synonymous with "community".

Crocker and Wood (1947) define an association as "the constant association (i.e. growing together) of dominant species recurring in similar habitats". The term "dominant species" includes both tree and shrub or herb layer species which give the community its characteristic look. The association is made up of smaller units, the type and society. The type is a local change in dominants of the upper stratum, with little or no change in other dominants. A society is a local change in lower stratum dominants. It is clear from these definitions that the

type is more the fundamental unit and an association is a collection of related types (Crocker and Wood, 1947, p. 126). Although the definitions of the equivalent terms of Beadle and Costin (1952) on one hand and Crocker and Wood (1947) on the other, are not the same, the corresponding units approximate fairly well in fact.

If this last scheme is applied to the objective communities previously determined by Goodall's method (1953), the following classification in Table 3 is obtained.

THE ENVIRONMENT

1. Climate

The whole of the southern part of South Australia experiences a Mediterranean type climate with summer drought and winter rainfall. January and February are usually the driest, hottest months with June to August the wettest, coldest period. The moisture-laden winds come from the south-west and altitude induces condensation as the air masses rise over the Mt. Lofty Ranges.

TABLE 3

Classification of the Five Objective Communities

<table>
<tr><th>Community</th><th>Society</th><th>Type</th><th>Association</th><th>Formation</th><th>Edaphic Complex</th></tr>
<tr><td>I</td><td>Pultenaea daphnoides-Platylobium obtusangulum</td><td>E. obliqua-E. elaeophora</td><td>E. obliqua</td><td rowspan="5">Dry Sclerophyll Forest</td><td rowspan="5">"Stringybark"</td></tr>
<tr><td>II</td><td>Pimelea spathulata-Pultenaea largiflorens</td><td rowspan="3">E. elaeophora-E. fasciculosa</td><td rowspan="4">E. elaeophora</td></tr>
<tr><td>III</td><td>Xanthorrhoea semiplana-Hakea rostrata-Leptospermum myrsinoides</td></tr>
<tr><td>IV</td><td>Lepidosperma semiteres</td></tr>
<tr><td>V</td><td>Hibbertia sericea-Acacia pycnantha</td><td>E. elaeophora</td></tr>
</table>

The pertinent aspects of the climate are summarised in Fig. 16, which shows the mean monthly rainfall, sunlight, evaporation, temperature and frost for a nearby meteorological station, Mt. Crawford.

Rainfall and insolation, which directly affects evapotranspiration, were critically examined over the experimental area.

(1) *Rainfall.* Coote and Cornish (1958) correlated mean monthly rainfall with position and altitude of observing stations in part of South Australia. By using the regression coefficients obtained in this analysis, the mean monthly rainfall can be calculated for any known position and altitude within the Adelaide Hills (see Appendix). In this way the mean annual isohyets were constructed for this area (see Fig. 15). The accuracy of these coefficients is claimed to be high and altitude is the chief factor influencing the results.

The mean monthly rainfall data of four nearby recording stations – namely Tea Tree Gully, Millbrook, Kersbrook, and Mt. Crawford – were compared with the estimates calculated from the regression equations of Coote and Cornish (Martin, 1960). There are discrepancies which could be due to local factors, such as the effect of topography on wind turbulence and consequently rainfall (Rayson, 1957). The estimated isohyets (Fig. 15) unfortunately ignore these local factors.

A statistical analysis of the mean annual rainfall, estimated to fall at 50 sites throughout the area, showed that the rainfall varied significantly from one

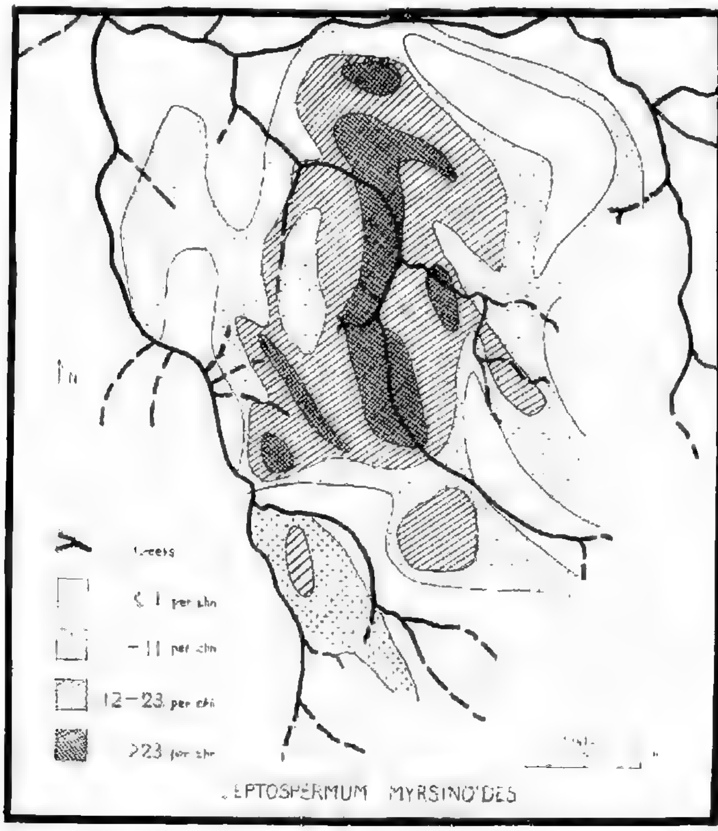

Fig. 7. *Leptospermum myrsinoides.* This species is widespread in distribution with large areas of higher densities.

community to another (P less than 0·1 p.c.). Communities I and IV received the highest rainfall (32·26 and 32·61 inches per annum respectively), communities II and III over an inch less (31·11 and 31·03 inches per annum respectively), while community V received the lowest rainfall of 29·89 inches per annum (see Table 4).

(2) *Insolation.* With a hilly topography, aspect differences are often important. In order to determine the insolation received by different slopes the method used by Rayson (1957) was followed. A scale model of the area was examined under a solarscope (Phillips, 1949), which simulates the movement of the sun across the sky. From the shadows the hours of sunlight per day were

TABLE 4

Summary of Environmental Factors

Community	Classification: Type	Classification: Association	Rainfall (in.)	Sunlight (Hours/day): Pre-Noon	Sunlight (Hours/day): Post-Noon	Sunlight (Hours/day): Total	Fertility (g. D.W. per oat plant)	Rate of Evapo-transpiration (regression coefficient)	+Annual Evapo-transpiration (in.)	+Drainage (in.)	Maximum storage (in.)	Growing Season (months)
I	*E. obliqua-E. elaeophora*	*E. obliqua*	*32·26*	*4·7*	5·1	9·8	0·049	*Higher (−0·051)*	22·27	9·99	*3·90*	*11*
II	*E. elaeophora-E. fasciculosa*	*E. elaeophora*	31·11	*4·8*	5·1	9·9	0·053	Lower (−0·035)	22·44	8·67	5·77	12
III			31·03	5·2	*4·6*	9·8	0·046	Lower (0·035)	24·16	6·87	6·80	12
IV			*32·61*	5·4	5·2	*10·6*	0·054	Lower (−0·037)	22·88	9·73	5·42	12
V	*E. elaeophora*		++29·89	5·3	5·0	*10·3*	*0·099*	+++Lower (−0·042)	20·94	8·91	4·84	12
Probability			<0·1%	1·0–0·1%	1·0–0·1%	1·0–0·1%	<0·1%	<0·1%			5·0–2·0%	<0·1%

+++ Community V would have been even lower if it had been burnt as well as the other four.

++ A third group, different from each of the other two.

+ Evapotranspiration and drainage are the composite result of vegetation, rainfall and maximum storage capacity and not independent factors in themselves.

estimated. From Fig. 17 it can be seen that the higher elevations receive more insolation than the slopes and valleys, but there is no marked aspect differences between the north-east slopes and south-west facing slopes. However, Figs. 18 and 19 show that the north-east slopes receive the morning sun and the south-west slopes the afternoon sun. In the morning, when dew is present, sunlight will cause its evaporation, while in the afternoon it heats the vegetation and soil directly. In addition, afternoon temperatures are usually higher due to the lag between insolation and temperature. Therefore, the south-west slope is not more protected but could be subject to higher temperatures and more

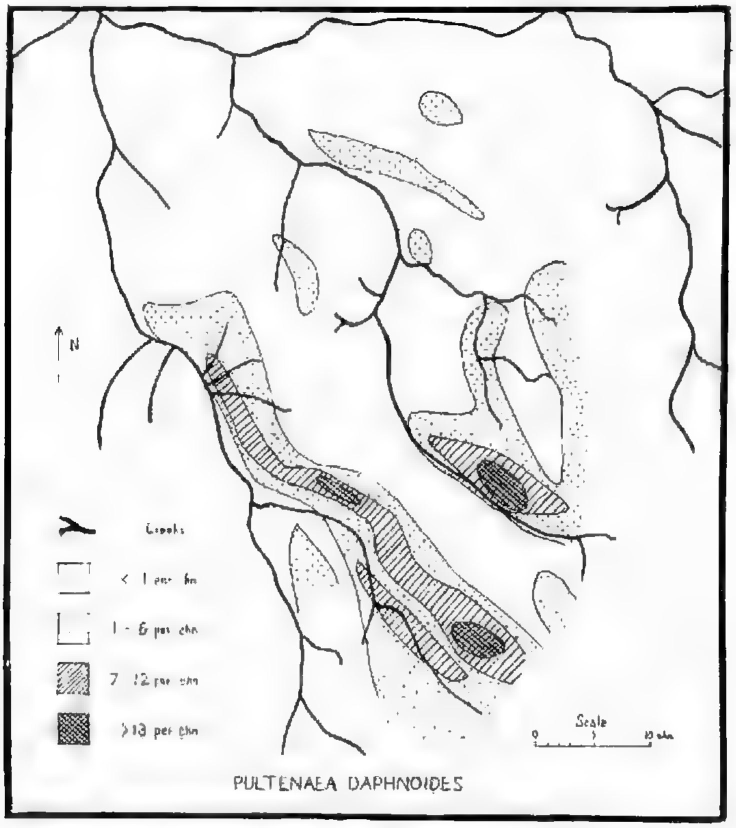

Fig. 8. *Pultenaea daphnoides.* Restricted in area, the distribution coincides well with that of *E. obliqua.*

drying conditions. Germination usually occurs in autumn, as soon as the rains come, and the amount of insolation at these times could have an important effect on the different species.

A statistical analysis shows no significant difference between the five communities for either pre-noon, post-noon or total sunlight. This is undoubtedly so because the variation is so great, as seen in Fig. 20. However, Fig. 20 also shows an aggregation of some communities. If communities I and II are grouped and tested against III, IV and V grouped, then there is a significant difference for pre-noon sunlight. In a similar fashion, community III is significantly different from the others, grouped together for post-noon. For the total, communities IV and V grouped against the others are signi-

ficantly different. Table 4 summarises this. The figures in italics form a group significantly different from those in clarendon and roman at the levels of significance shown.

The foregoing estimations of insolation assume continuous sunlight with no clouds at all. Clouding reduces light intensity but this probably would not be sufficient to reduce photosynthesis in summer, while in winter it could be

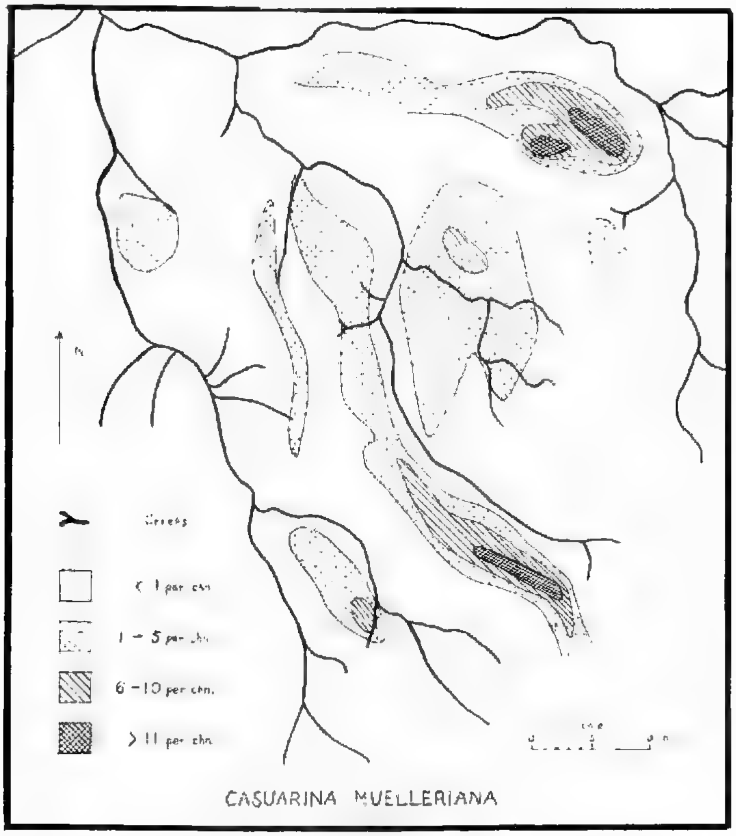

Fig. 9. *Casuarina muelleriana.* This species is not widely distributed and is present mainly on the northern aspects. The usual height is 4 feet in stands not fired for 12 years, but in much older stands, it reaches a height of 12 feet, as found in the most N.E. corner (see Plate 3A).

limiting. However, a cloud cover would reduce evaporation and this could be quite important in summer at times of high water stress.

The conclusion that the ridge is so orientated that aspect only slightly affects total insolation is supported by some limited soil temperature data. The temperature was recorded by thermistors (Aitchison, 1952a, 1952b, 1953) placed at depths of 6, 18 and 36 inches in the soil at four sites located (a) in the valley, (b) half way up the north-east facing slope, (c) on the ridge top, and (d) half way down the south-west facing slope. Temperatures were measured at approximately monthly intervals (Fig. 21).

Soil temperature readings one inch below the surface were taken directly with a thermometer. These readings fluctuated throughout the day closely approximating air temperature.

Statistical analysis showed no significant difference between plots for the 36 or the 18 inch depths. At the 6 inch depth, the ridge top, site (c), consistently showed significantly higher temperatures than the other three sites

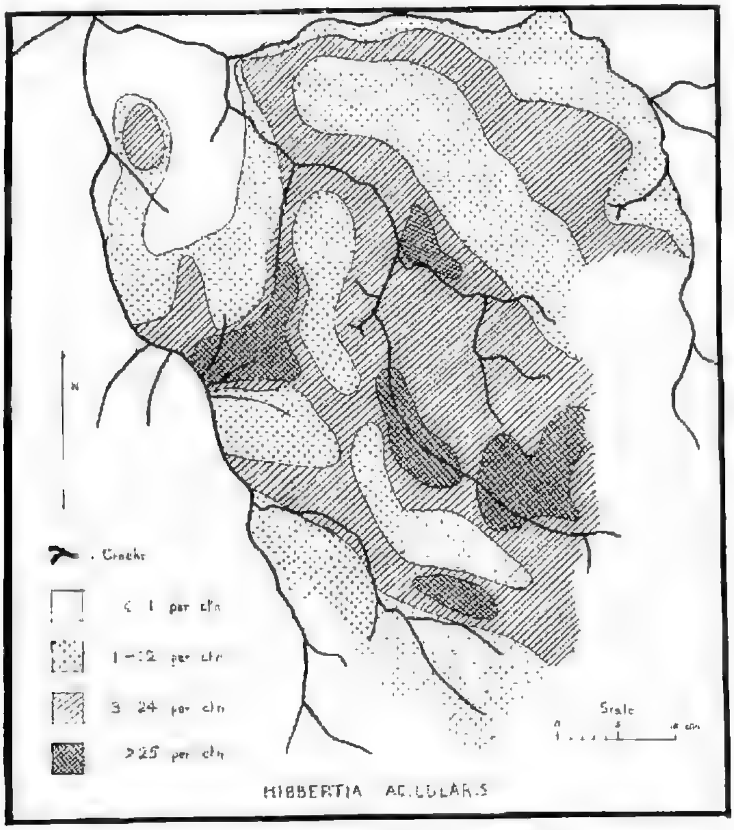

Fig. 10. *Hibbertia acicularis.* This species is widely distributed with large areas of high densities. It is absent only from the north-west end of the ridge.

(P less than 0·1 p.c.) indicating that only the more exposed ridge tops (where communities IV and V are found) receive greater insolation.

2. Geology

The area under study is situated on an inlier of the Archean complex, highly metamorphosed, sedimentary rocks, folded and contorted with igneous intrusions (Hossfeld, 1935; Spry, 1951). Miles (1950), investigating the site of a new dam about 8 miles north of the area, found this inlier to consist of phyllites, phyllite-schists and felspathic schists, interbedded with quartzitic or sandy facies. Lenses of quartz feldspar had also penetrated the rocks. The exposed rocks may be case hardened, but are otherwise soft and crumbly due to weathering. The feldspar content decomposes to kaolin (Miles, 1950) under conditions consistent with lateritisation (Stephens, personal communication).

3. Soils

(1) *Morphology of soils.* The soils which have formed upon these ancient phyllites and schists show well differentiated profiles. The A horizon, a loam, changes abruptly to the B horizon, a stiff clay, which grades to a soft friable decomposed rock. Hard rock is usually encountered at a depth of three to six feet.

The surface two or three inches, the A1 horizon, is dark grey or grey-brown in colour due to humus and organic matter. The amount varies from site to site, but most soils contain relatively little organic matter. The A2 horizon 12 to 15 inches in depth, is typically a clayey loam though some are sandy or silty textured. Most soils possess a rather fine crumbly structure and some, particularly the silty textured loams, are very fine and powdery when dry. All except the sandy A horizons are rather sticky and heavy when wet.

TABLE 5

Means and Regression Coefficients used in Estimation of Rainfall

$\bar{x}_1 = 6{\cdot}5360$ $\bar{x}_2 = 9{\cdot}478$ $\bar{x}_3 = 7{\cdot}558$

Month	$\bar{y}$	b_1	b_2	b_3
Jan.	0·97	0·03543	0·02420	−0·02898
Feb.	0·97	0·03604	0·02115	−0·03091
Mar.	1·03	0·04498	0·01342	−0·05616
Apr.	1·91	0·1099	0·03587	−0·1431
May	2·78	0·1704	0·06407	−0·2443
June	3·37	0·2271	0·08011	−0·2930
July	3·18	0·2190	0·1165	−0·2358
Aug.	3·13	0·2023	0·05716	−0·1966
Sept.	2·67	0·1576	0·06813	−0·1372
Oct.	2·10	0·1110	0·03526	−0·1043
Nov.	1·39	0·06330	0·01920	−0·06123
Dec.	1·11	0·04144	0·01560	−0·04198

A consistent feature of the A horizon is the accumulation of pebbles and gravel both on the surface and distributed throughout the horizon. Generally, the stones are the most resistant fragments of the parent rock, often showing iron stainings. The size of the fragments ranges from gravel to pieces a foot in diameter, sometimes giving the impression that bed-rock is close to the surface. However, after prising away several large rock slabs the normal B horizon extends down for two or three feet more. Lateritic gravel can be found in places, but it is not abundant over the area selected for intensive study. The B horizon, almost without exception, contains few rock fragments. As much as 30 to 40 per cent. rock by weight is common in the A horizon, while the B horizon rarely contains more than 5 to 10 per cent.

The B horizon is a stiff clay with very little structure which dries to form hard, solid clods and becomes very sticky when wet. The colours are mainly brown, reddish brown and brick red, occasionally yellow brown. Red mottlings are common, particularly in the upper half, but often the whole horizon presents a complex mottled pattern in red, yellow and brown. The colour gradually changes with depth, becoming more yellow, and this is usually associated with an increase in sand and coarse material due to more of the soft, friable decomposed parent rock. Just above hard bed-rock, many profiles show an accumulation of kaolin, three or four inches in depth.

Where the slope is steeper (roughly 20 to 40 degrees), on either side of the hill, the profile with A and B horizons, as described, may not always be developed. Instead, the soil is shallow, 12 or 18 inches deep and skeletal, showing no differentiation. This soil, however, is similar to the A horizon of the deeper, differentiated profiles. Outcrops of rock are common in such parts sometimes in the form of small cliffs.

Another type of soil occurs along the alluvial creek flats which are only narrow strips in this instance. The A horizon can be much deeper and more irregular, probably due to periodic flooding and silt deposition. These soils have not been further studied since they are atypical and small in area. The vegetation associated with the alluvial soils is also quite different—fewer

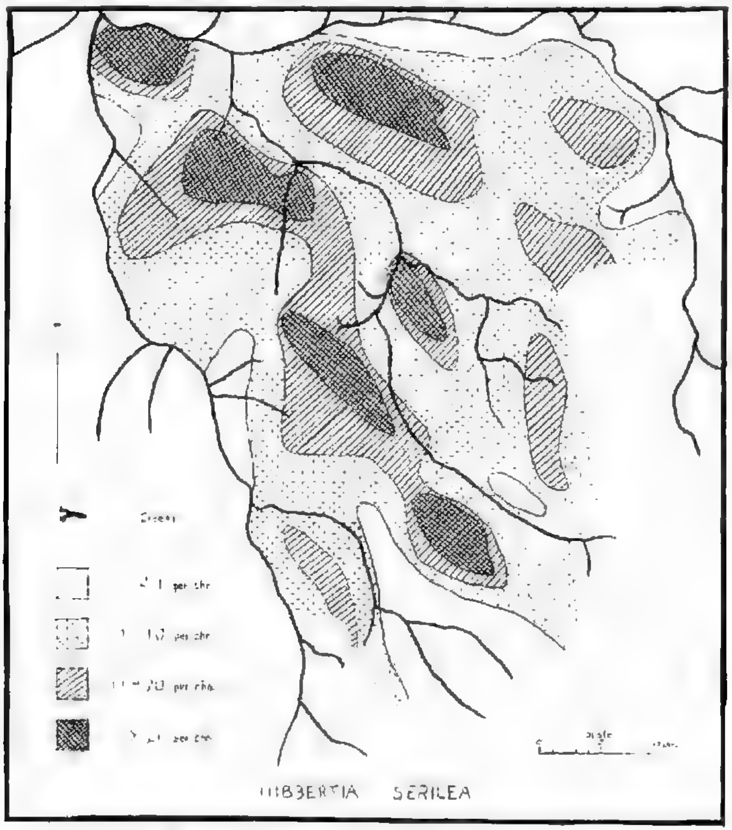

Fig. 11. *Hibbertia sericea.* Distribution is widespread. The regions of higher densities are usually on the ridges.

sclerophyll species and more grasses, often with *Eucalyptus camaldulensis* as the dominant.

It is clear from the foregoing descriptions that these soils show many of the features associated with lateritisation. The lateritic gravel, the abundant iron stainings, the red mottlings of the B horizon and the accumulations of kaolin in the deeper layers, together with low fertility and acid reaction, are all consistent with laterite formation. The majority of the soils undoubtedly belong to the great soil group, lateritic podsolic soils (Stephens, 1953), formed in past ages (Pliocene?) when the climate was more humid, but variously truncated in more recent times.

The area being studied came within a soil survey made by Jackson (1957). Under his classification these soils fall within the Mount Gawler Soil Association which is confined to the rugged, hilly country with frequent rock outcrops.

(2) *Fertility of soils.* It is well known that lateritic podsolic soils are not fertile, and sclerophyllous vegetation is generally regarded as indicative of a soil with a low nutrient content. Working with pastures on this type of soil, Trumble and Donald (1938) found that yield was proportional to phosphorus added, and recommended a dressing of 2 cwt. of superphosphate per acre

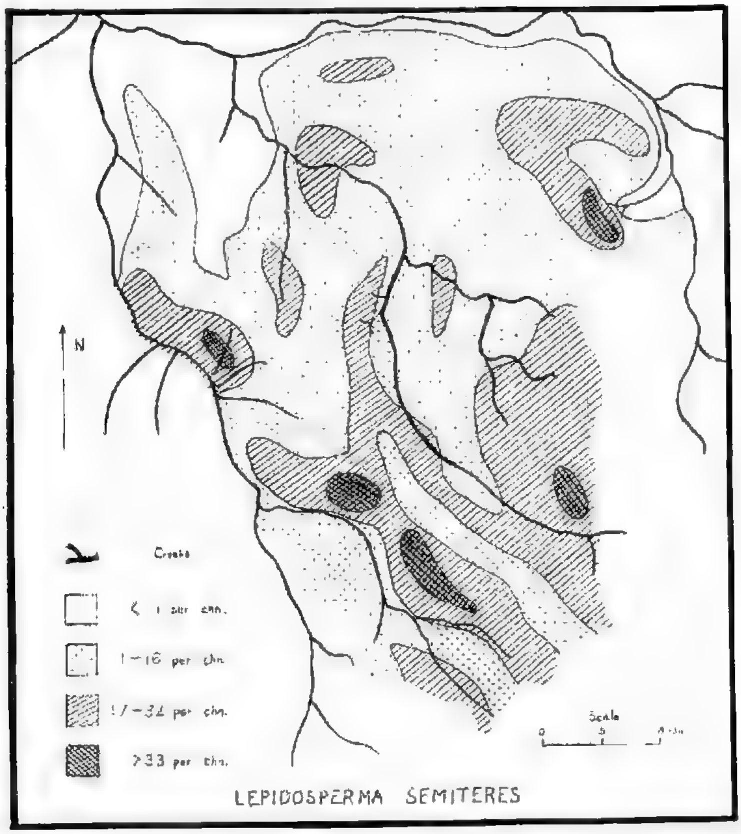

Fig. 12. *Lepidosperma semiteres.* This species covers most of the area, but is absent from the northern ends of the ridges. The densities are higher to the south.

yearly. However, some pastures did not flourish on this treatment and Anderson (1946) found that the addition of 1 to 2 oz. per acre of molybdenum trioxide was necessary, particularly for a good growth of legumes. Also, analytical data on the Mount Gawler Soil Association showed 0·006 to 0·023 per cent. total phosphorus and 0·03 to 0·20 per cent. total nitrogen (Jackson, 1957). Thus it was decided to investigate soil fertility to see if variations in this factor influenced the distribution of sclerophyllous species.

For the estimation of fertility, there are several approaches. One is chemical analysis, but this is very laborious, particularly if a number of soils are to be estimated, and the results can give a false picture. The amount of a nutrient available to the plant may vary from that estimated chemically and

species differ in their ability to utilize the different forms of an element (Russell, 1950, and Moore, 1959). A second method makes use of some plant as an indicator. With this approach, the productivity results from the integration of many factors of the soil, chemical and physical. There are limitations with

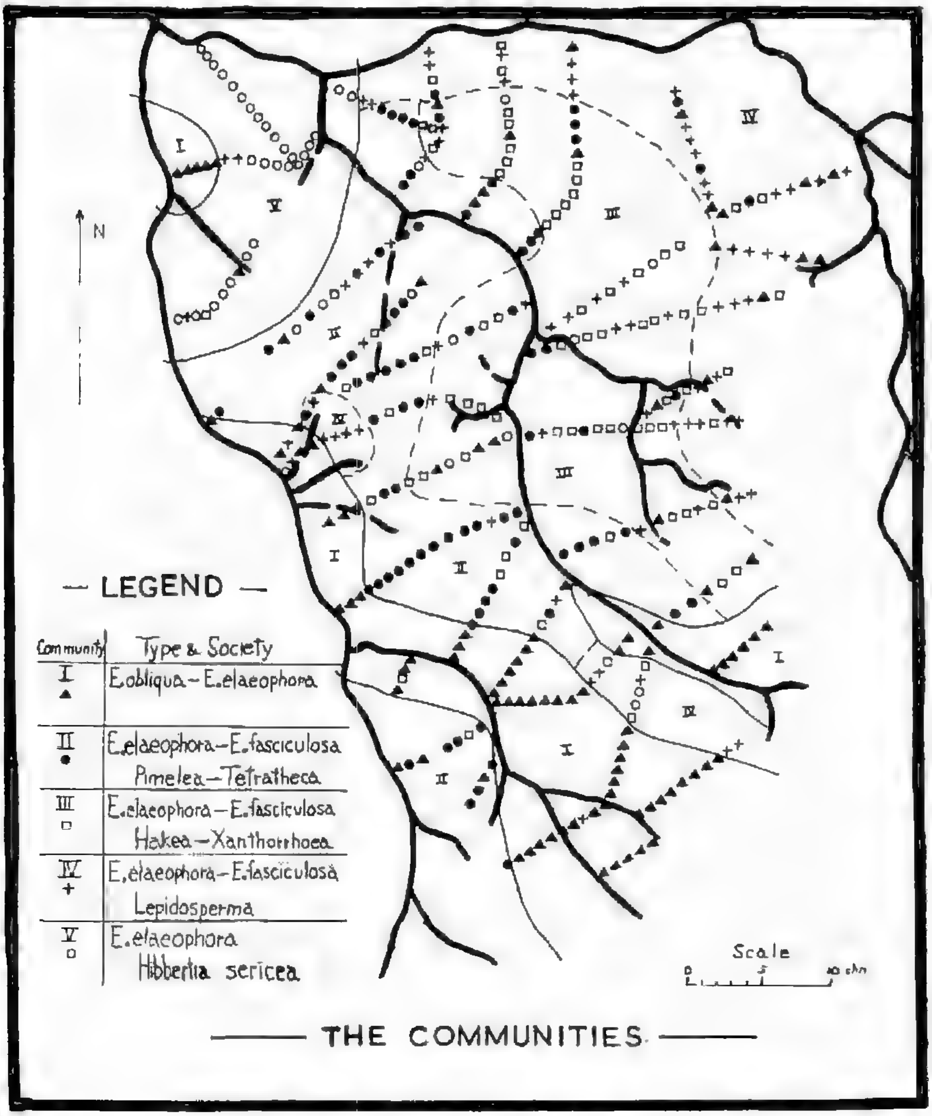

Fig. 13. The distribution of the objective communities.

this method, too, and the results are influenced by the indicator species chosen and conditions during the experiment. However, with the same species and environment for all samples, the results from one soil can be compared with those of another. Moore (1959) has used this method to determine the nutrient status of soils from several natural communities in New South Wales. This biological method was chosen, using oats as the indicator species.

Large samples of soil were collected from 120 random sites, from the surface down to 9 inches. The soil was air-dried, sieved and 1,600 g. put into 6-inch flower pots, with three replicates for each soil. Each pot was seeded with oats, Mulga variety, which were allowed to grow for 9 weeks, the soil moisture content being kept at approximately 60 per cent. saturation throughout the trial. The tops of the oats were then harvested, and the results expressed as dry weight per plant.

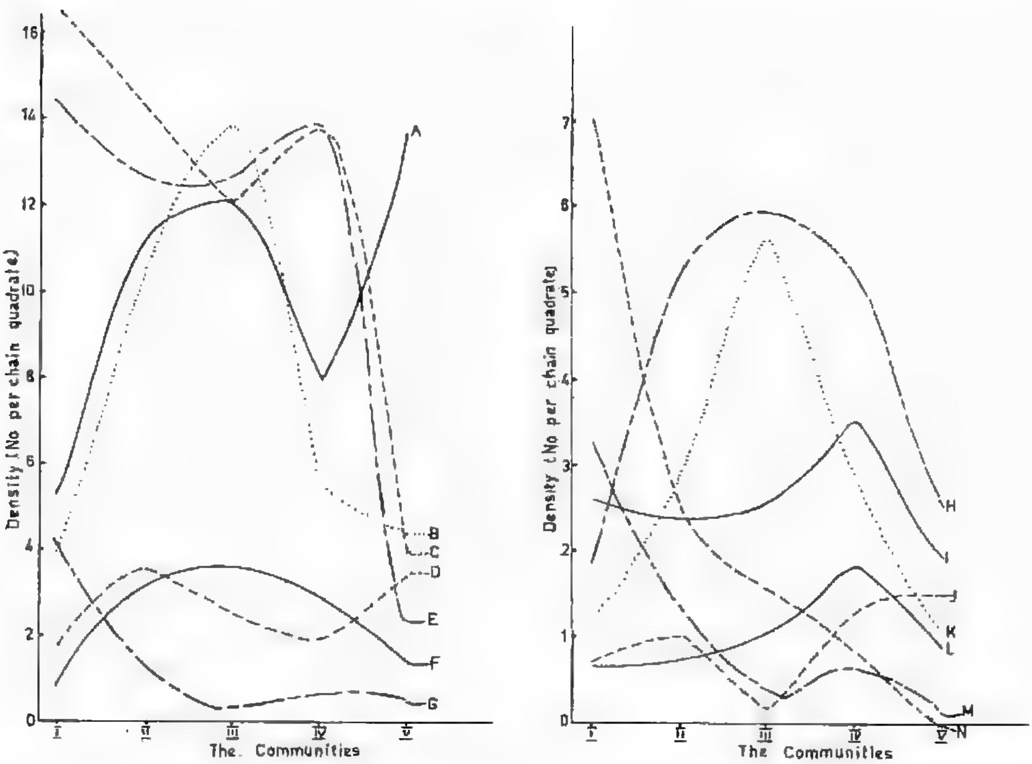

Fig. 14. *The Continuum.* The density is plotted against the communities, arranged in order from south to north. Key to species: A, *Hibbertia sericea*; B, *Leptospermum myrsinoides*; C, *Lepidosperma semiteres*; D, *Eucalyptus elaeophora*; E, *Hibbertia acicularis*; F, *Eucalyptus fasciculosa*; G, *Eucalyptus obliqua*; H, *Xanthorrhoea semiplana*; I, *Pultenaea largiflorens*; J, *Acacia pycnantha*; K, *Hakea rostrata*; L, *Casuarina muelleriana*; M, *Pultenaea daphnoides*; and N, *Platylobium obtusangulum*.

The results were grouped into the respective communities and an analysis of variance showed that oat plants grown on soil from community V were significantly larger than those grown on soil from the rest of the area (Table 4).

Increased growth, however, need not be due to fertility alone. It was noted that the texture of the A horizon was often sandy or silty loam in soils where greater growth occurred. When a 2×2 test was applied on these soils against clayey loam soils and the higher growth class and the lower growth classes, a very significant correlation of $\chi^2 = 45 \cdot 04$ was obtained. Thus, increased growth could have been due to a better texture which may have allowed greater root development, water penetration, or some other factor beside soil fertility.

4. Water Relationships

In this climate, with long summer droughts, water, or rather the lack of it, is perhaps the most important single environmental factor. From the end of October onwards, rain falls only in light sporadic showers and during this time plants depend largely on what water there may be stored in the soil. The

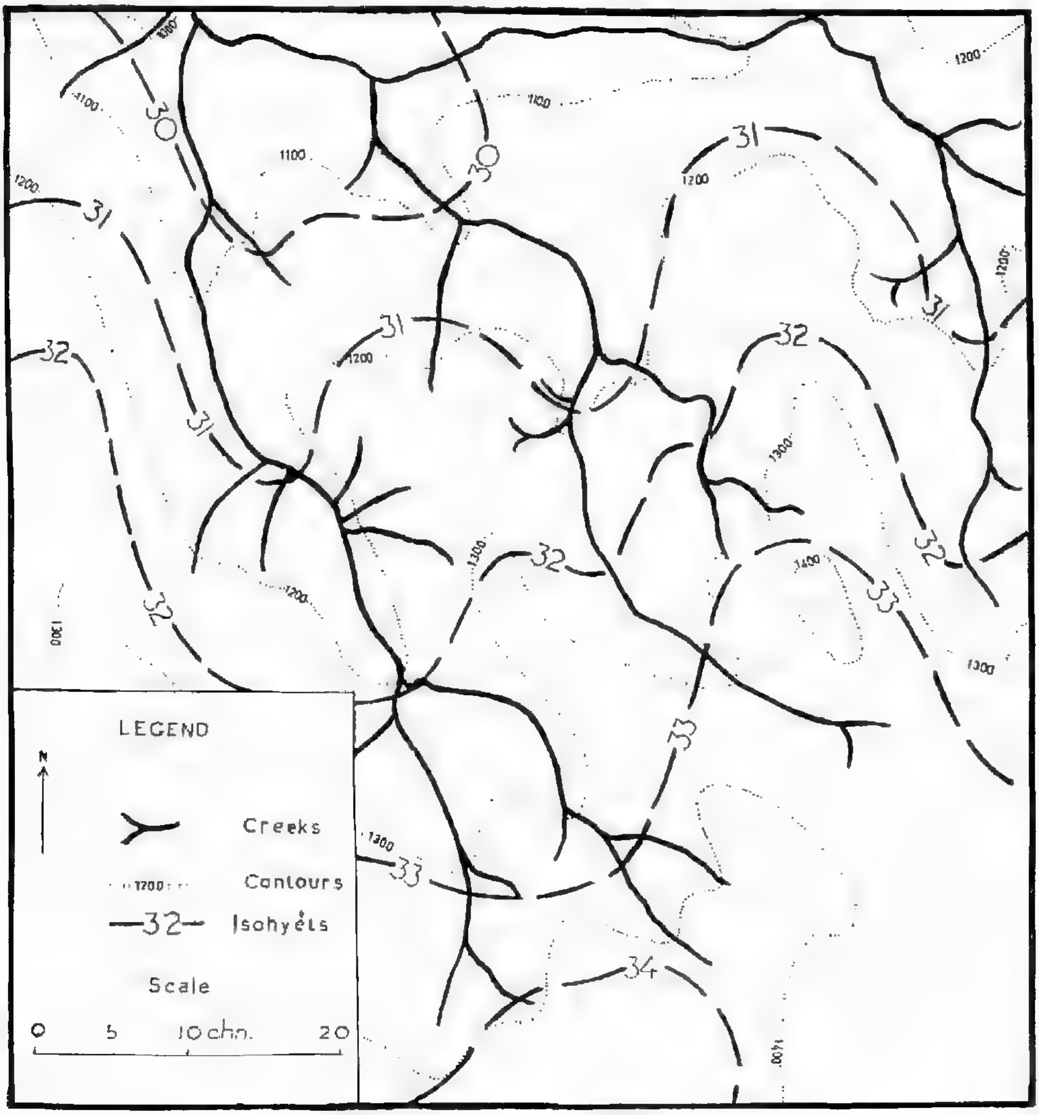

Fig. 15. *Map* showing contours and estimated annual rainfall isohyets. It can be seen that altitude is the main factor influencing rainfall, estimated by these means.

amount of reserve soil moisture depends chiefly on the preceeding winter rainfall. In a good season, the whole profile reaches field capacity and water drains away into the substratum. However, in a poor season with rainfall well below average, the wetting front may not penetrate right down the full depth of profile. This means that the soil five or six feet deep may not receive any water

for two or more years, depending on the seasons. An experiment was designed to investigate the soil moisture, the rate at which it was depleted, and if possible, differences from one community to another.

The soil moisture was measured over the central-ridge and the actual evapotranspiration evaluated for each of the five communities (Martin, 1961). It was found that community I possessed significantly higher evapotranspiration than all the others, viz.

Community I: Log $(2{\cdot}4 - I_{tr}) = 0{\cdot}264 - 0{\cdot}051\ (W - 2{\cdot}63)$.

Communities II + III + IV + V: Log $(2{\cdot}4 - I_{tr}) = 0{\cdot}261 - 0{\cdot}036\ (W - 3{\cdot}29)$.

Although the index of evapotranspiration (I_{tr}) has been plotted against avail-

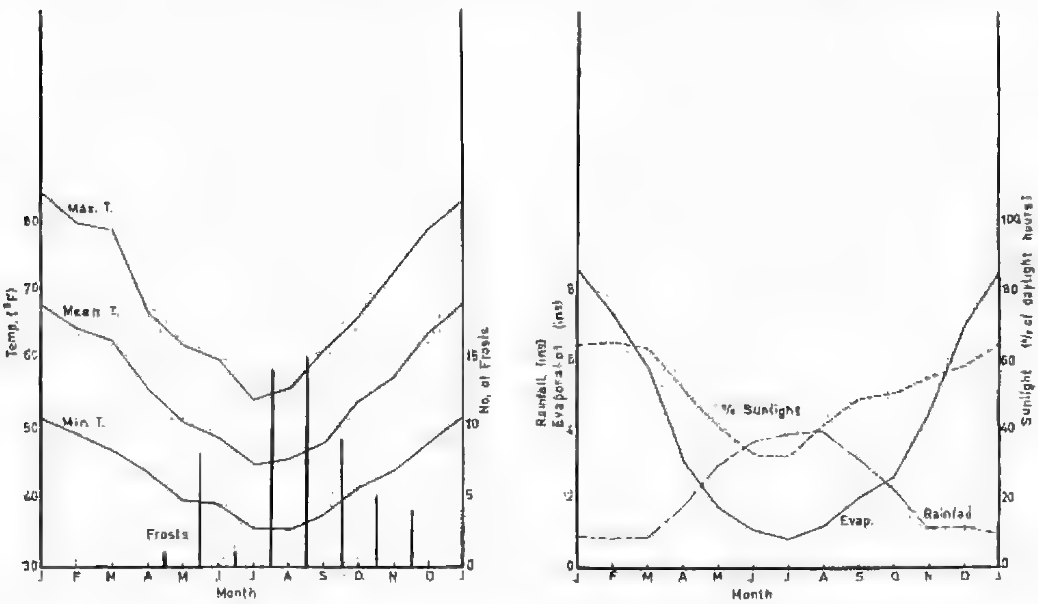

Fig. 16. *Rainfall, Mean Temperature, Frequency of Frosts,* Evaporation (Ew − 21 × s.d.) and Percentage Sunlight.* All the data was obtained from Mount Crawford, except sunlight, which applies to the Waite Agricultural Research Institute. * The number of frosts are the figures for 1957.

able water (W), the same values of evaporation from a free water surface were used for all five communities. Hence the actual evapotranspiration shows the same relative difference as that for the index.

From soil moisture, rainfall and evapotranspiration, the water regime was followed, month by month (Martin, 1961). The result was that every plot in community I, showing the higher evapotranspiration, exhausted the soil moisture completely and had to survive one month of drought. This was not so for communities II, III, IV or V, which by virtue of their lower evapotranspiration, dissipated the supply more slowly and thus did not create a drought for themselves. The data are summarised in Table 4.

A conspicuous feature of the data was the occurrence of community I on soils with less available water, i.e. a lower maximum storage capacity. It seems logical to conclude that if the supply of water is less, then a longer drought will ensue. However, this is not so since the actual evapotranspiration is restricted according to the water supply. Thus a site with a maximum storage

capacity of 2 inches loses much less water by evapotranspiration than one with a 6·6 inch capacity, even though the rates are the same (Martin, 1961). The length of the drought is the result of the rate of evapotranspiration and not the maximum storage capacity.

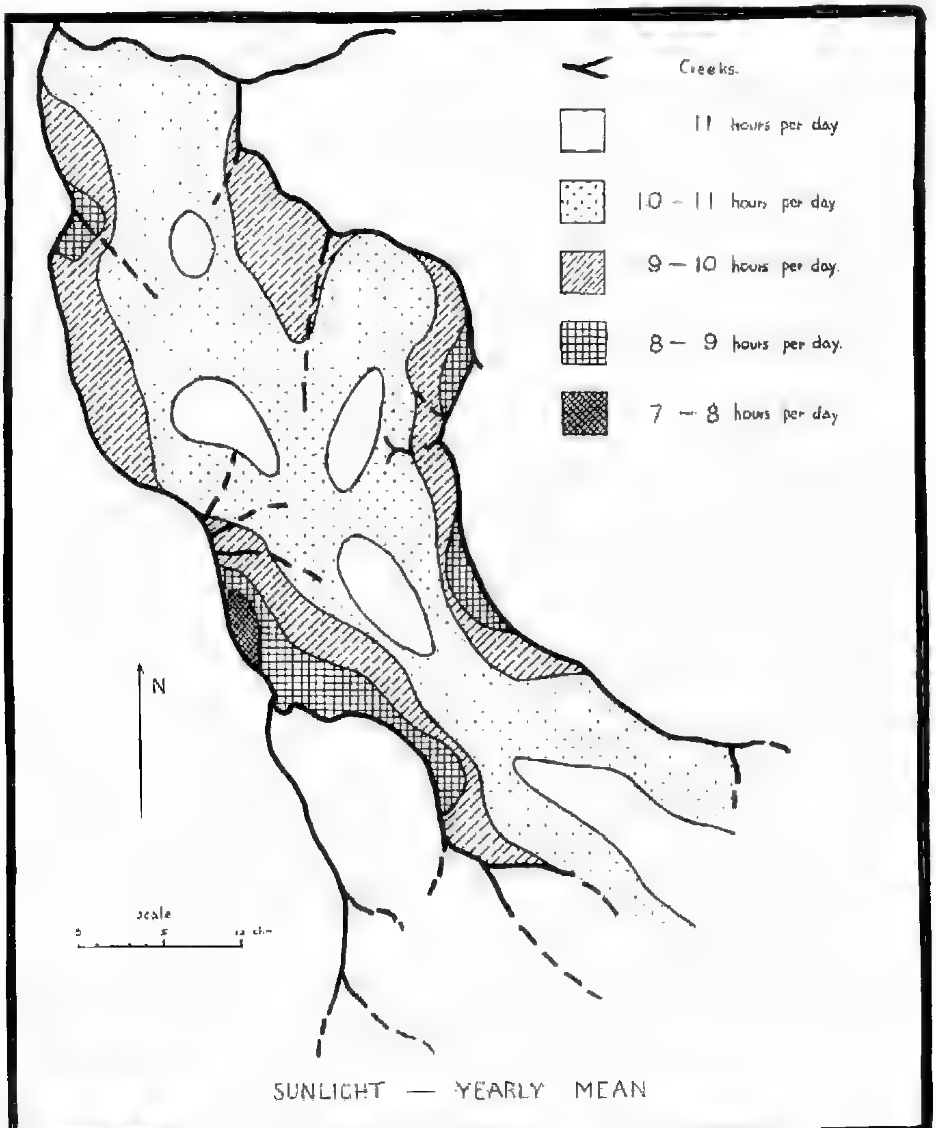

Fig. 17. *Yearly Mean Sunlight or Insolation.* There is practically no difference in aspect from one side of the ridge to the other. The top of the ridge receives more insolation.

All the foregoing remarks apply to the soil above bedrock. Particularly at the sites with shallow soil, 1 to 2 feet deep, it is obvious that tree roots are not confined to the soil alone. Observations at Mount Crawford Forest (Woods, 1958) show that tree roots penetrate the country rock, a soft schist or gneiss

with bedding planes which dip at 30 to 80 degrees. Whether the water relationships of roots in rock fissures is comparable to roots in soil is a matter for conjecture, as precise data would be very difficult to obtain. In any case, an additional unknown amount of water could be available in the country rock.

The figures given in Table 4 apply to an average year and do not indicate the effect of critical drought periods. In years with below average rainfall, the soil may not reach maximum storage capacity so that during the following summer moisture reserves become depleted much earlier. At Mount Crawford, Woods (1958) found that if another such year followed, then drought deaths were high and many trees were permanently damaged so that they failed to respond when

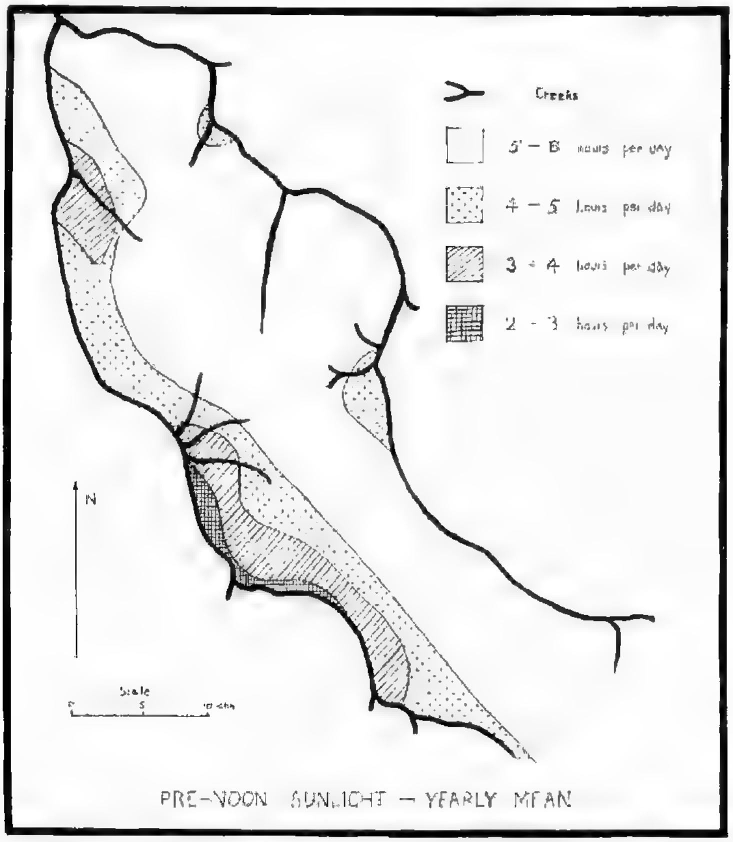

Fig. 18. *Yearly Mean Pre-noon Sunlight.* The north-eastern side of the ridge receives the morning sunlight when temperatures are lower.

good rains came. In addition, deaths due to drought were more frequent on the exposed ridges with shallower soils than on more protected slopes and deeper soils. Of course these observations were for the introduced *Pinus radiata,* but the native vegetation would be subject to similar stresses. Thus the critical drought years could be more important than the many average years.

The effect of drought would always be greater in community I because the higher evapotranspiration depletes the moisture reserves more rapidly. Consequently these plants of community I are subject to greater stresses and must of needs be more drought resistant than the other communities which conserve

the available moisture by a lower evapotranspiration as well as growing on deeper soils with a greater storage capacity, though this does not affect the length of drought directly.

DISCUSSION

The original aim of this study was to find some explanation of the distribution of sclerophyllous species observed in the field. Each major species was recorded by means of isoline maps. The communities were objectively determined and classified. Various environmental factors were recorded within the communities and compared from one to another community.

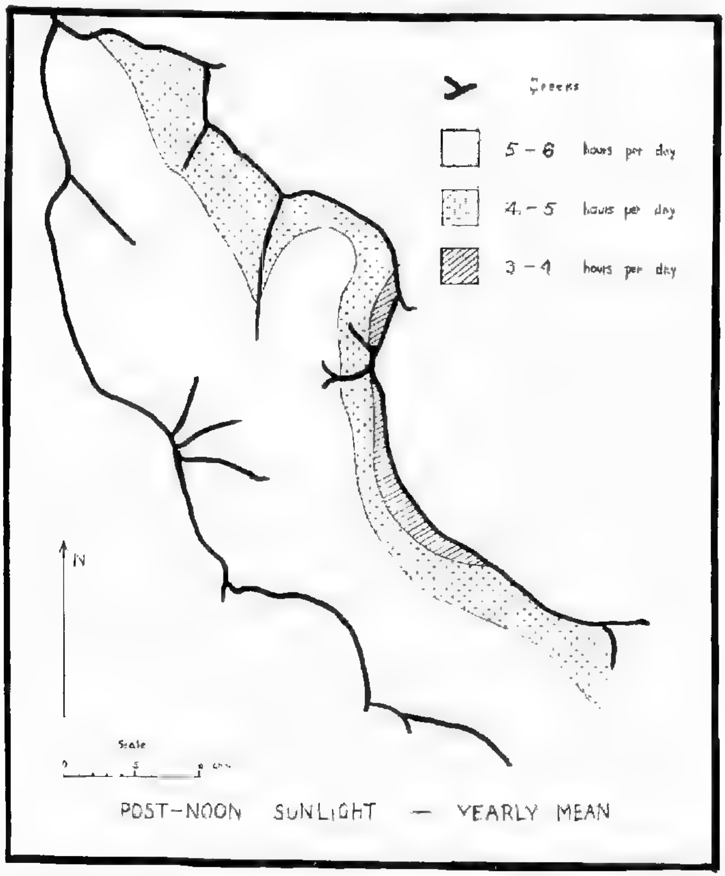

Fig. 19. *Yearly Mean Post-noon Sunlight.* The south-western slope receives the afternoon sunlight when temperatures are higher.

In the objective method used to determine the communities, the results depend to some extent on the standards chosen. With the values originally used by Goodall (1953) of P = 1·0 p.c., seventeen communities were obtained — a completely unworkable result. By adjusting the level of significance to P = 0·1 p.c., only five communities were obtained and these could be classified satisfactorily. But this was based purely on the presence or absence of a species. Had some allowance been made for the abundance of a species, e.g. above or below the mean, the results could have been different again. How-

ever, it is unlikely that the pattern of the communities would have been radically altered since these objective methods delimit communities which are real and recognisable in the field. In a subjective estimation, community I with its *Eucalyptus obliqua* and abundance of small shrubs is easily recognised. Community V is distinguished by its paucity of many species. Community III with the higher densities of large shrubs is also easy to recognise, but this is not so with II and IV, which do not differ greatly from III. In the field it is possible to subjectively group these three together into one large community.

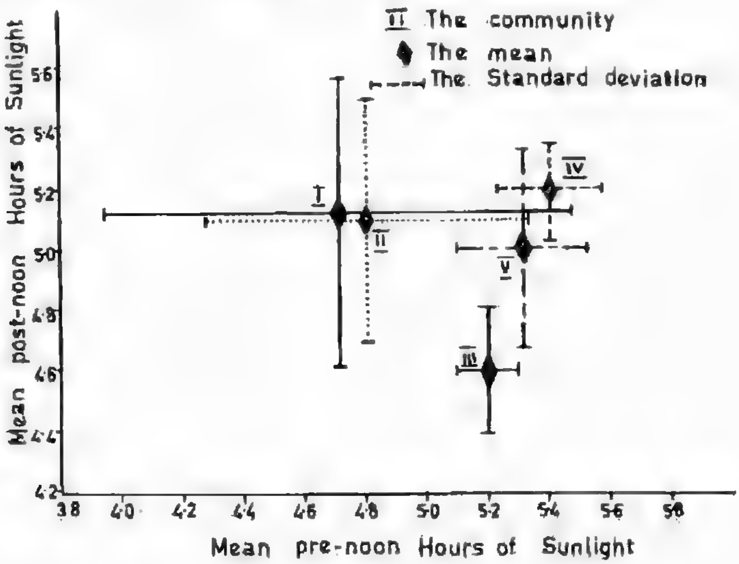

Fig. 20. *Yearly Mean Insolation Received by the Communities.* Communities I, II and III receive less than IV and V. There is a wide variation.

The five communities have been classified into three types:

(1) *E. obliqua-E. elaeophora* type with community I;
(2) *E. elaeophora-E. fasciculosa* type with communities II, III and IV, each of which is a society;
(3) *E. elaeophora* type with community V.

The three types were further classified into two associations:

(1) *E. obliqua* association containing the *E. obliqua-E. elaeophora* type; and
(2) *E. elaeophora* association with the remaining two types, viz. the *E. elaeophora-E. fasciculosa* type and the *E. elaeophora* type.

Can these communities be explained on the basis of the environmental factors studied? Table 4 summarises the statistical differences which have been detected. The figures in italics form a class significantly different from those in clarendon and roman type.

Thus community I receives a higher rainfall and less sunlight, particularly pre-noon. Although no figures are available, the temperature and evaporation would be less since insolation is less, especially for the pre-noon period. Hence the environment for this community is more mesic. But, the vegetation possesses a higher rate of transpiration and depletes the water supply earlier so that it must survive one month of drought. This is rather paradoxical in that a more mesic vegetation seems to be inherently or physiologically more drought resistant as well. The effect of the higher rate of evapotranspiration is even more

significant with regards to seedling establishment. The conditions of drought created by the members of community I, already in possession of the area, may well prove too rigorous for large numbers of would-be invaders (Martin, 1961). The maximum storage capacity is less, though this has no direct effect on the drought period. In addition, the soil fertility is low.

Communities II, III and IV are not easily separated since they possess the same lower rate of evapotranspiration, the same maximum storage capacity and the same low soil fertility. With the lower evapotranspiration, the stored moisture is not completely exhausted and hence there is no drought period at all in an average year. However, communities II and III receive less rainfall but less insolation as well. Community III with the greatest density of large shrubs is particularly notable in that the post-noon insolation, when temperatures and

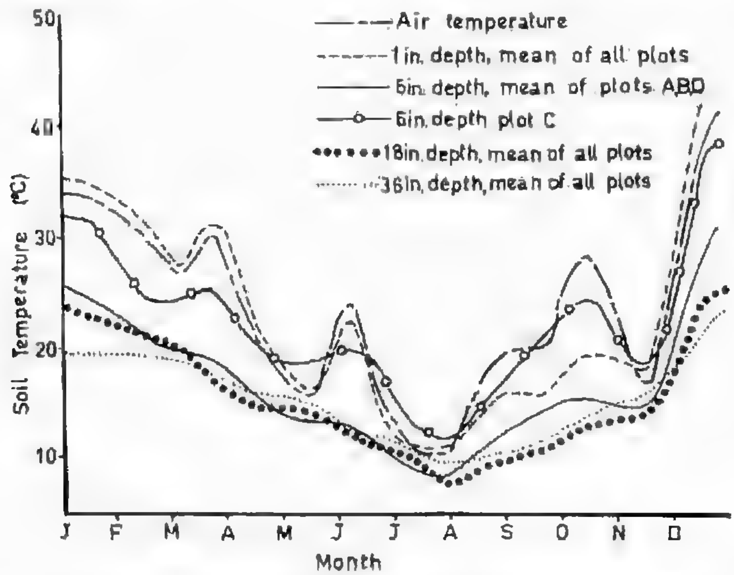

Fig. 21. *Yearly Soil Temperature Regime.* The curves are the means of all plots except for the 6-inch level where plot C is significantly higher than the others.

exaporation are higher, is markedly less. Community IV, on the other hand, receives a greater rainfall and a greater amount of insolation which would reduce its effectiveness by increasing temperature and evaporation. It is interesting to note that the floristics of community IV are in many ways intermediate between III and V. In the respect of insolation and presumably temperature and evaporation, community IV is similar to V. The fact that these three communities, II, III and IV, are difficult to separate on environmental factors is not surprising since they are classified as societies within the same type.

Community V is quite distinctive from the others. The rainfall is in a class on its own, lower than any of the others and soil fertility is higher. In view of the higher fertility, it is not surprising that the floristics of this community show certain affinities with the savannah woodland – sclerophyll forest transition communities. The typical sclerophyll species are much reduced in number and *Acacia pycnantha*, a savannah woodland species, is more common. The insolation, and hence temperature and evaporation, is also higher. While the measured rate of evapotranspiration is the same as that for II, III and IV,

evidence (Specht, 1957) indicates that had this community been burnt as well as the others, the rate would be even lower (Martin, 1961). Because of the lower evapotranspiration, there is no drought period and the maximum storage capacity is not different from II, III and IV.

The communities were originally arranged along a continuum based on the floristics. A continuum can be seen in many of these environmental factors which, in a broad sense, parallels the floristic continuum. The rainfall is higher to the south, decreasing to the north. It is the reverse for insolation, lower to the south and higher to the north.

All these calculations have been made for the central ridge only. Would they apply to the whole area originally surveyed? They would apply to the communities which were well represented on the central ridge, viz. I, II and V. However, communities III and particularly IV, may show some differences if the broad north-east ridge is included. Figs. 13 and 15 indicate that the mean rainfall for community IV would be reduced considerably while the insolation would be at least as great. For community III, though the total insolation may not be changed by much, the pre-noon and post-noon ratio would be different (Fig. 20). The rate of evapotranspiration would be the same since this is largely determined by the vegetation.

These results indicate that there are no marked environmental differences governing the communities, but rather a trend or difference in degree. Still, the differences between the communities themselves are not great either. Statistical differences do not automatically indicate the cause of observed phenomena and other factors which do not lend themselves to measurement and analysis could have quite an important bearing on the question. There is evidence that at one time the tree canopy was much better developed — before white men started their activities in the district. With the removal of trees, increased light would stimulate the understory and increase the density of sclerophyllous species. Whether there has been differential cutting out of the trees and whether the sclerophyllous species respond differentially is a matter for conjecture. Another factor is the chance dispersal and establishment of a species which then excludes or prevents other species from growing there even though the environmental conditions are favourable. This could easily be the case with the dense *Xanthorrhoea semiplana* stands, and possibly with the sward of *Lepidosperma semiteres* and *Lomandra fibrata*.

This objective study reveals many interesting facts about the vegetation, but only partly answers the question as to the cause of the observed distributions. The answer may lie in some important undiscovered factor but the communities are more likely to be the result of many integrated facets of the environment. When studied one at a time, the complex relationships of diverse factors are hard to detect.

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APPENDIX

The Estimation of Mean Monthly Rainfall

For the calculation of mean monthly rainfall, the form of the regression coefficient was as follows:

$Y = \bar{y} + b_1(x_1 - \bar{x}_1) + b_2(x_2 - \bar{x}_2) + b_3\,(x_3 - \bar{x}_3)$ (Coote and Cornish, 1958).

where Y is the rainfall in inches (for the particular location),

b_1, b_2, b_3 are the regression coefficients for altitude, latitude and longitude respectively;

x_1, x_2, x_3 are the values for altitude (in 100 ft. units), latitude and longitude respectively. Latitude and longitude were in 10^{-1} degree units after subtracting the whole number of degrees, e.g. 138·5625 deg. = 5·625;

$\bar{y}$, $\bar{x}_1$, $\bar{x}_2$, $\bar{x}_3$ are the corresponding means of all stations.

Dr. E. A. Cornish kindly supplied the regression coefficients and means which are given in Table 5.

A. The coppiced habit of *Eucalyptus obliqua* which is cut periodically can be seen clearly. The bases of the trunks are blackened due to a bushfire some 4½ years previously. The understory consists of the grass-like *Lomandra fibrata*, *Hibbertia acicularis* and small plants of *Platylobium obtusangulum* (Community 1).

B. Part of the understory seen in Plate 1A. *Lomandra fibrata* forms a "grass-like sward" with some *Hibbertia acicularis*, a little *Lepidosperma semiteres* and a small plant of *Platylobium obtusangulum* (near ruler).

A. Old tussocks of *Lepidosperma semiteres* are seen in this unburnt region with leaf litter and dead twigs. Other species present are *Hibbertia acicularis* and *H. sericea* (Community II).

B. The trees are *E. elaeophora* with some *E. fasciculosa*. The understory consists of abundant *Xanthorrhoea semiplana* and *Hakea rostrata* with occasional *Leptospermum myrsinoides* and only a few small shrubs, mainly *Hibbertia* spp. (Community III or II).

A. This plate shows a stand of old *Casuarina muelleriana* which has not been burnt for 25 years or more. The proportion of dead material on the plant is high, some being quite dead (foreground). This spot is located in Community IV, the north-east corner

B. Part of the low, ground covering layer, rather sparse in this instance. The species are *Hibbertia sericea* and *H. acicularis* with an occasional *Lissanthe strigosa* and *Lepidosperma semiteres*, the latter as very small plants. Large shrubs are absent here (Community V).

FIELD RELATIONSHIPS OF THE ANABAMA GRANITE

BY R. C. MIRAMS

Summary

The Anabama Granite intrudes and metamorphoses the Adelaide System in the southern section of the Olary 4-mile military sheet. This granite is distinct from and younger than other granites described elsewhere in the Olary Province. The field relationships of the granite to the surrounding Adelaide System and to the associated dykes and rnetamorphism are discussed.

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by R. C. Mirams*

[Read 8 June 1961]

SUMMARY

The Anabama Granite intrudes and metamorphoses the Adelaide System in the southern section of the Olary 4-mile military sheet. This granite is distinct from and younger than other granites described elsewhere in the Olary Province. The field relationships of the granite to the surrounding Adelaide System and to the associated dykes and metamorphism are discussed.

INTRODUCTION

The Anabama Granite outcrops in the southern portion of the Olary 4-mile sheet across the boundary of the Manunda and Anabama 1-mile sheets (Fig. 1). The granite is exposed sporadically through superficial deposits over an area 20 miles by an average of 5 miles (Fig. 2), most of which lies on the Anabama 1-mile sheet. In mapping the Manunda 1-mile sheet (Mirams, 1960) it became evident that mapping of portion of the Anabama 1-mile sheet would be necessary to determine the relationship of the granite to the Adelaide System. Consequently detailed mapping of the western portion of the intrusion was undertaken.

A review of published material suggested crystalline rocks to be an Archaean core in a major anticlinal structure. The State maps (Sprigg, 1953a, 1953b) showed the granite massif and Archaean metasediments occupying an anticlinal structure. Sprigg (1954, p. 12) discussed the occurrence under the heading of Willyama Complex without mentioning the granite. On p. 16 he states, "Near Anabama Hill, swarms of granite dykes have risen through the local Sturtian unconformity", but in the text does not relate these dykes to the Anabama Granite.

Petrological examinations have been carried out by officers of the Australian Mineral Development Laboratories and the reports are included in the Appendix.

THE GRANITE

The massif includes a variety of rock types ranging from coarse-grained porphyritic or pegmatitic, to fine-grained dense leucocratic rock. The predominant rock type is a medium- to coarse-grained, unstressed granite. In places a weak foliation is observed in weathered material, but this is not typical of the granite. In addition, there are marginal variations due to incomplete assimilation of the Adelaide System country rock. These are seen along the northern contact near Gap East Well (Netley Gap Station) where quartzites, resistant to assimilation, form enbayments in the granite. Similar rock types found away from the contact are thought to be due to the proximity of the roof of the granite mass. Where rafts of sediments are found within the intrusive no clear boundary

* Geological Survey of South Australia, published with the permission of the Director of Mines.

can be defined. The contact zone, often only a few feet wide, grades from granite to a quartz muscovite rock resembling a greisen.

STRUCTURAL RELATIONSHIPS OF THE GRANITE

The granite intrudes the folded Sturtian Series of the Adelaide System in the deepest part of a synclinal trough (the Anabama Syncline). The area examined in detail (Fig. 1) is in the vicinity of the (northern) contact with the lower and interglacial sequence. The mapping shows that the granite north of Netley Hill intrudes the southern limb of a synclinal trough running east-north-east from Oratan Rock. Netley Hill consists of greisenized rocks of varying composition. These rocks do not appear to have been disturbed during the intrusion and now appear as an erosional remnant of a roof pendant within the granite mass.

The structure of the area strongly suggests that the Netley Hill "greissen" outcrops represent the metamorphosed quartzitic phase of the lower glacial tillite (Sturt Tillite). These "greisen" are similar to those found at Anabama Hill and near Gorge Well. The latter are interpreted as the outcrop of the same horizon on the other limb of the Anabama syncline. This interpretation is supported by the presence of Upper Torrensian (?) slates between this range and the Willyama Complex outcropping to the south-east.

RELATIONSHIP WITH NEAREST INTRUSIVE GRANITES

This is the only granite massif in the Olary region known to intrude the Adelaide System. Several unstressed intrusive granites are known in the Olary Province to the north-east, but none are known to intrude the Proterozoic. Campana (1958, p. 42) states that no granitic rocks related to the early Palaeozoic orogenic cycle have been recognized in the Olary Province, although hydrothermal veins, related to this cycle, are widespread.

It is likely that the Anabama Granite is genetically related to the granites outcropping near Truro-Mannum-Monarto, and Palmer. However, detailed comparisons have not been attempted by the writer. Superficial similarities with features of the Mannum Granite (Goode, 1927; Alderman, 1929) have been noted, namely:

(1) Composition; dominantly pink orthoclase with quartz plagioclase and biotite.
(2) Prominent outcrops may be interpreted as small cupolas belonging to a larger massif.
(3) Alderman suggests the Mannum Granite may not agree in composition with the granite mass from which it may be an offshoot. Similar discrepancies in composition are evident between specimens taken from the Anabama Granite near Netley Gap and near Anabama Hut.

DYKES

The regional distribution of the dyke suite has been outlined by Sprigg (loc. cit., p. 17), who suggested that they may have been emplaced above a deep-seated magma chamber.

Four phases of dyke activity have been recognized near Gap East Well.

(1) *Lamprophyres*

These dykes are probably older than a metasomatic phase of the granite now found to outcrop nearby. Near the granite they are cut by later pegmatites and intermediate dykes and have not been found intruding the granite. The dykes are medium-grained, micaceous rocks of basic composition. They are described in thin section P603/59 and P606/59 in the petrological descriptions appended.

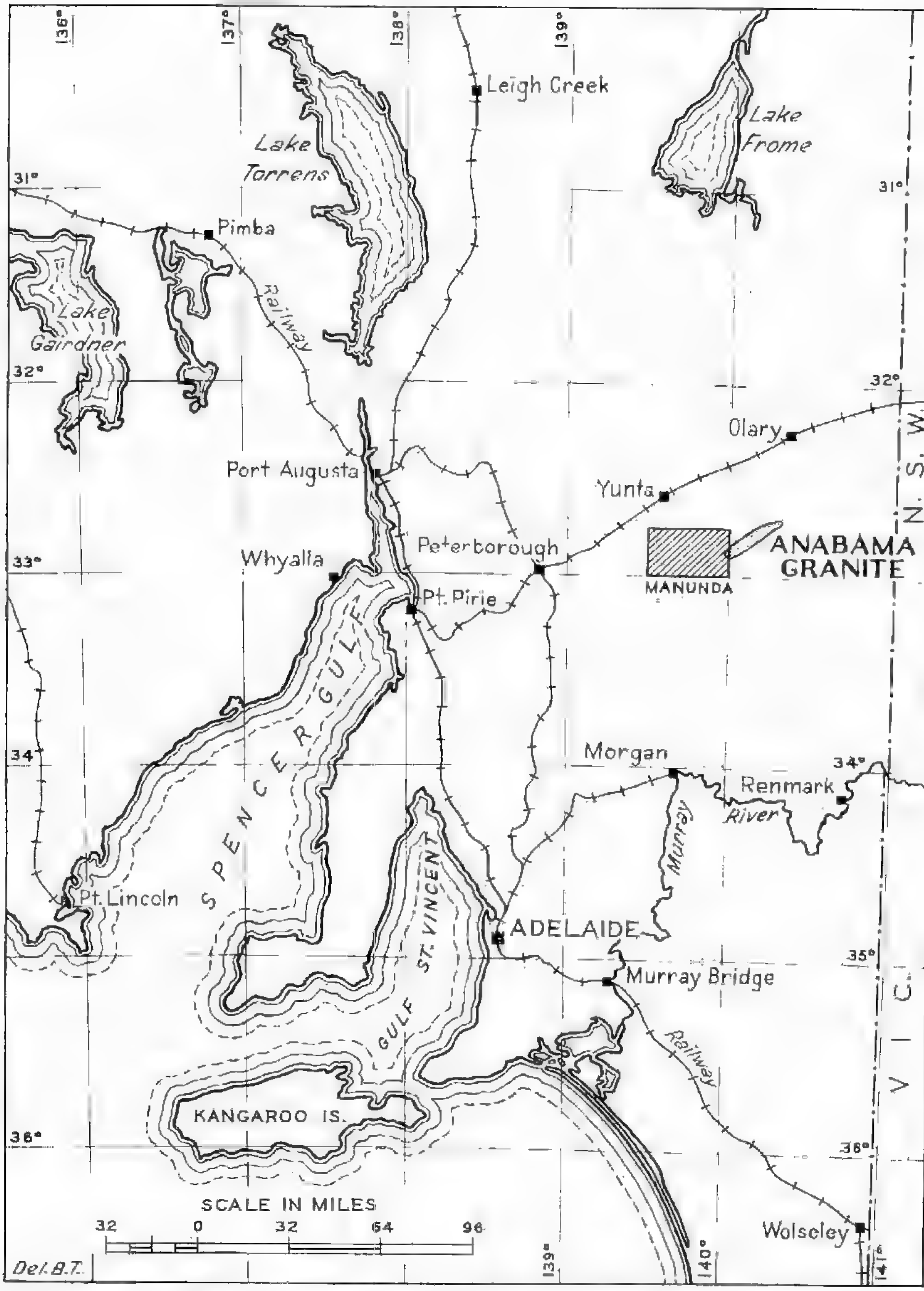

Fig. 1. Locality plan, showing location of Manunda 1-mile geological sheet and the Anabama Granite.

(2) *Pegmatitic-leucocratic dykes*

These grade from normal coarse pegmatites to fine-grained leucocratic dykes. There is more than one phase of these dykes as they are seen to intrude one another. They are found intruding the granite and along the contact as well as intruding the Sturtian sediments.

(3) *Intermediate dykes*

Light grey-green dykes described petrologically as "Iron-alkali rich igneous rocks metamorphosed to the lower greenschist facies". (P1022/59, P1023/59.) These dykes can be traced back into the granite as intrusions. They also cut the pegmatites and micropegmatites.

(4) *Pale grey-green felspar porphyries*

These may be the same phase as (3) but have a very fine-grained ground mass speckled with coarse white felspar crystals.

Intense metasomatic activity predates the (stage (3)) dyke intrusions. Where these dykes intrude what is now "greisen" they have not been subjected to the intense metasomatism that has altered the sediments.

The dykes are not affected by the folding of the Adelaide System, but have been subjected to the stress which induced a low grade metamorphism in the adjacent sediments.

METAMORPHISM OF ADELAIDE SYSTEM

The metamorphic effects of the intrusion on the Adelaide System are extremely variable. The rocks above the granite mass have been extensively metasomatized and in general converted to quartz muscovite rocks akin to greisen. As stated earlier, where granite is found adjacent to greisen there is no clear line of demarcation.

To the west, where the granite is probably at shallow depth, a tongue of metamorphosed Sturtian rocks extends south-west crossing the Lilydale-Manunda road south of Oratan Rock.

The presence of younger granite at moderate depths could also explain the incipient metamorphism and numerous quartz veins of the Adelaide System to the west on Manunda 1-mile sheet. The same granite is the probable source of the felspathic alteration and metasomatic addition of titanium and boron in the upper glacial sequence near Old Grampus Ruins, Manunda Station.

The north contact shows low grade metamorphism (P604/59) (P605/59), with restricted development of hornfels. The dykes have been metamorphosed to a similar facies (lower greenschist) as the country rock suggesting that this phase of metamorphism postdates the igneous activity.

The metasomatized Adelaide System rocks at Anabama Hill are those appearing as Archaean (Willyama Series) on the State Map. Willyama rocks occur at "The Brothers", two hills farther to the south and do not appear on the State Map.

CONCLUSION

The Anabama granite is a post-Sturtian intrusive body probably of early Palaeozoic age. The granite intrudes a major syncline. The emplacement is thought to be a dry intrusion accompanied by overhead metasomatic replacement as there is little evidence of the temperatures expected from a normal intrusive melt. The granite is related to the orogenic cycle that folded the Adelaide System and developed towards the end of the cycle.

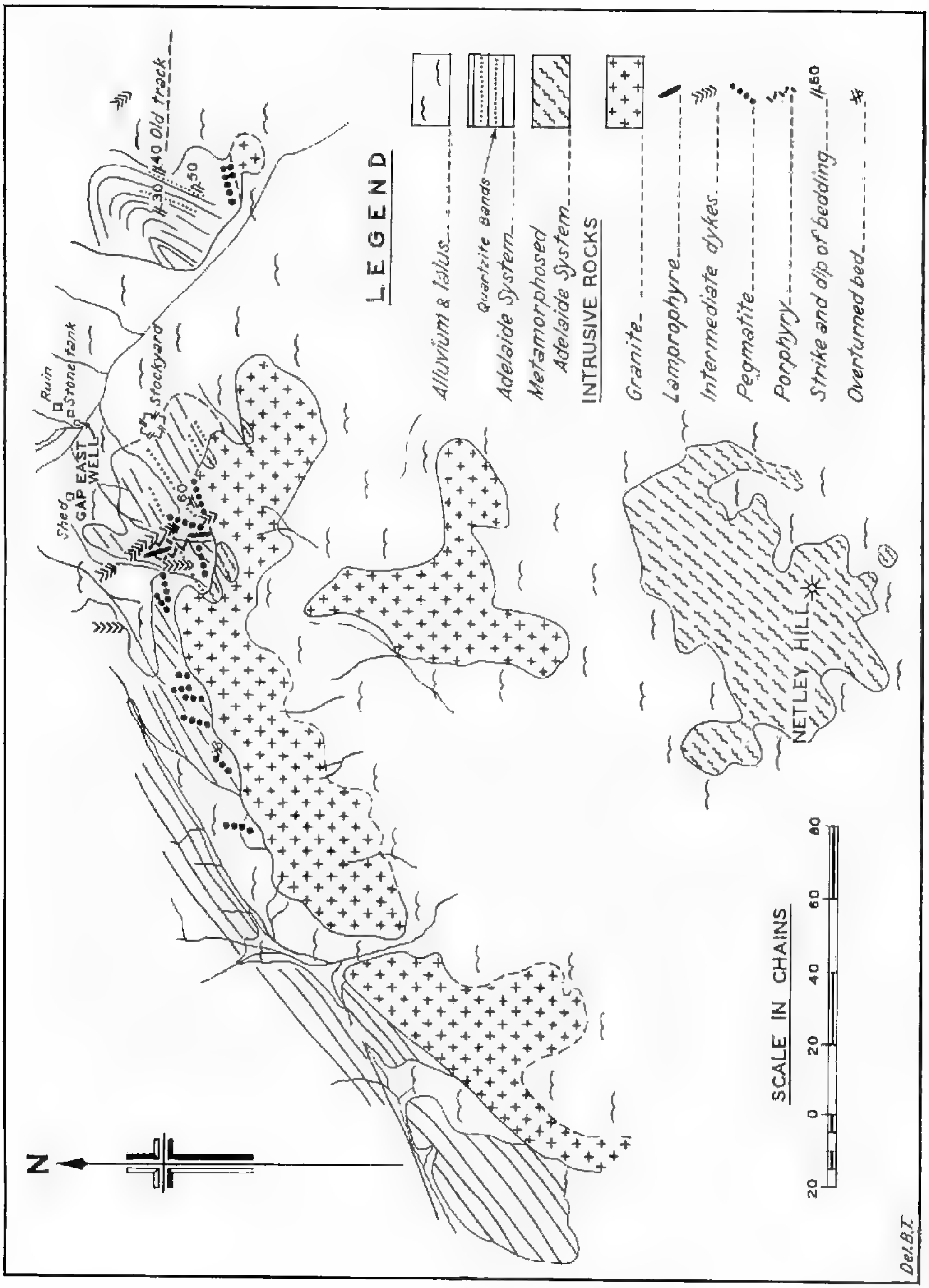

Fig. 2. Geological plan south of Gap East Well showing the Anabama Granite outcrop.

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APPENDIX

Petrological reports on specimens from the Anabama Granite and associated rocks submitted by the writer and others are included. The reports are grouped in the manner the rock types are treated in the text, namely:

1. Granite Specimens.
2. Dyke Specimens.
3. Metasomatic Rock Specimens.
4. Metamorphic Rock Specimens.

GRANITE SPECIMENS

P674/58. *Location*: 9 miles WSW of Anabama Hut. *Collected by*: B. P. Thomson. *Examined by*: M. J. Bucknell.

This leuco-adamellite has two generations of crystals. The larger grains are of strained quartz, microcline (sometimes with microperthite), orthoclase, and minor albite-oligoclase. The latter has normal zoning. Myrmekitic textures, with radiating exsolution bodies of potassic felspar, or muscovite, occur locally. The grain size of the larger crystals is 1-4 mm.

Interstitially, there are 100-500 micron crystals of strained quartz, microcline, and iron-rich biotite; the biotite has opaque ferruginous matter inter-leaved or occurring as isometric grains.

This rock is of the same general type and composition as the Crocker Well alaskite, although some of the latter appear to be more sodic. The textures of the Crocker Well series are also variable, but some are similar to P674/58.

It should be mentioned that many of the coarser felspar grains enclose rounded quartz crystals, and may be therefore of metasomatic origin.

P1175/59. *Location*: Mulga Paddock, Manunda Station. *Collected by*: R. C. Mirams. *Examined by*: M. J. Bucknell.

Composition:

Quartz, 1-3 mm.	55 p.c.
Sericite (after felspar), 1-5 mm. patches	35 p.c.
Muscovite (Fe-bearing), 0·3-1 mm. across	5 p.c.
Residual felspar	3 p.c.
Goethite/opaques	1 p.c.

Texture: The quartz grains are stressed and occur mainly in aggregates. Both the sericite and muscovite are unusual in having a high refractive index. They form the green patches seen in hand specimen, and are probably iron-bearing. The coarser muscovite also has inter-leaved opaque grains. This mica is probably due to hydrothermal alteration.

Classification: Granite, subject to stress and hydrothermal changes.

P606/60. *Location*: Gorge Well, Lilydale Station. *Collected by*: R. C. Mirams. *Examined by*: R. F. La Ganza and R. A. Both.

The constituents of this rock are quartz 40 p.c., microcline and perthite 40 p.c., hornblende 15 p.c., biotite 5 p.c., and minor epidote, sphene and muscovite.

The rock is a granite which has reacted with the country rock to form epidote and sphene. Large grains of microcline and perthite (1 mm. wide) contain inclusions of quartz and muscovite and are commonly silicified and sericitized. The quartz grains exhibit a wide range of size and are irregular in shape, displaying no stress.

P607/60. *Location*: Gorge Well, Lilydale Station. *Collected by*: R. C. Mirams. *Examined by*: R. F. La Ganza and R. A. Both.

The constituents of this rock are quartz 40 p.c., muscovite and kaolin 30 p.c., microcline 15 p.c., albite 15 p.c., and minor biotite.

The rock is a coarse-grained granite with the felspar extensively altered to sericite and kaolin, the plagioclase being the most altered. The quartz forms irregular grains with no signs of stress.

DYKE SPECIMENS

Lamprophyres.

P603/59. *Location*: Half mile SW Gap East Well, Netley Gap Station. *Collected by*: R. C. Mirams. *Examined by*: M. J. Bucknell.

Composition:

Biotite, 100 x 500 microns	30 p.c.
Hornblende, up to 500 microns	30 p.c.
Quartz, 50-250 microns	30 p.c.
Albite, 50-250 microns	5 p.c.
Sphene	ea. 1-2 p.c.
Apatite	ea. 1-2 p.c.
Potash Felspar	trace
Epidote	trace
Opaque	trace
Zircon	trace
Muscovite	trace

Texture: The amphibole, which is sodic, is irregular in form and distribution. The larger grains have inclusions of quartz and felspar. The golden-brown biotite occurs in flakes arranged at random. There are inclusions of rounded sphene (with pleochroic haloes) and opaque grains. Sphene also occurs with the quartz and felspar, as do the semihedral apatite crystals.

Classification: Related to the lamprophyres, although few of the characteristics of that type are present (compare P606/59). The shortage of felspar is due to the consumption of alkalis in the biotite and hornblende that were formed first. There may have been extensive hybridization.

P606/59. *Location*: Magpie Paddock, Netley Grap Station. *Collected by*: R. C. Mirams. *Examined by*: M. J. Bucknell.

Composition:

Biotite, 20 x 100 microns-1 mm.	40 p.c.
Albite-oligoclase, 30 microns	55 p.c.
Opaques associated with biotite	3 p.c.
Quartz, 30 microns	3 p.c.

Texture: The biotite forms idiomorphic (monoclinic) crystals and laths of various sizes. These are often corroded, and have a marked zoning with dark central and outer margins and an intermediate zone which is pink to orange and almost non-pleochroic. Sometimes the central dark zone is missing. The zones are sharply defined. The smaller laths are locally parallel exhibiting flow-texture. Locally there are concentrations of biotite, after basic xenoliths.

Classification: Lamprophyre (var. Kersantite). The rock exhibits nearly all the characteristic features of this group as described in the literature. It is probably a hybrid.

This rock differs from a lamprophyre from Radium Hill (P835/58-TS4058) in the following ways:

(1) Twice as much biotite.
(2) Felspar is plagioclase instead of orthoclase. The Radium Hill rock appears to have very little soda.
(3) Absence of apatite.

P606/59 is distinguished from P603/59 by:

(1) More soda and potash.
(2) Abundant hornblende in the latter.

Intermediate

P1022/59. *Location:* Half mile SW Gap East Well, Netley Gap Station. *Collected by:* R. C. Mirams. *Examined by:* M. J. Bucknell.

Composition: Sericitized K-felspar and saussuritized plagioclase, with epidote (pistacite), chlorite (Fe-Mg = 2 : 1), apatite, iron oxides, and traces of hypersthene.

Texture: The original plagioclase is granular, and the K-felspar often forms monoclinic euhedra, which may have grown under subsequent metasomatism. Both types of felspar are highly altered. Chlorite forms fan-shaped aggregates and apatite occurs as euhedral rods and prisms.

Classification: The original rock was an iron-alkali-rich basic igneous rock probably a norite. At some stage potassium metasomatism may have occurred. The rock was then metamorphosed to a low level of the greenschist facies under high water pressure, causing the retrograde development of chlorite, sericite, and saussurite (epidote and albite).

P1023/59. *Location:* Two miles SW Netley Gap H.S. on Manunda Road. *Collected by:* R. C. Mirams. *Examined by:* M. J. Bucknell.

This was originally a later-stage derivative of the magma that produced M.U 45. There is abundant quartz, more sericite, and less epidote.

Classification: Iron-alkali-rich intermediate igneous rock, metamorphosed to lower greenschist facies.

METASOMATIC ROCK SPECIMENS

P455/58. *Location:* Anabama Hill. *Collected by:* M. N. Hiern. *Examined by.* N. Chebotarev.

This is a completely *felspathised quartz-muscovite* rock which may be considered to be the result of the metasomatic replacement of a sedimentary rock. In thin section it presents a granoblastic mass of felspar, quartz and colourless mica. The felspar is a prominent constituent which forms about 60 p.c. of the rock. It consists of recrystallized microperthitic mass thickly crowded with finely disseminated iron minerals. Minor constituents include quartz, tending to be porphyroblastic and large crystals of muscovite. scattered at random through the rock. There are numerous cavities which are filled with crystals of jarosite, rimmed around by amorphous colloform silica. Large patches of barite and limonite may be seen occasionally. The other rock is a granoblastic quartz muscovite rock which may have originated from a gritty sediment. The rock consists of a recrystallized groundmass of quartz in which are embedded idioblasts of muscovite and porphyroblasts of quartz. The muscovite occurs as large and ragged terminated crystals full of inclusions of quartz. The fine cavities of the rock are encrusted with crystals of colourless mica or limonite.

P673/58. *Location*: Two miles SSW Oratan Rock, Manunda Station. *Collected by*: B. P. Thomson. *Examined by*: M. J. Bucknell.

A felspathic or felspathic sandstone has been metamorphosed to the amphibolite facies. Most of the rock is an interlocking mosaic of quartz, the individual grains varying from 0·25-2·5 mm. in diameter. Orthoclase and minor oligoclase occur interstitially: they may have been part of the original sediment, but if formed by metamorphism (of pelitic matter) or metasomatism, a temperature high in the facies is indicated. Diopside and actinolite hornblende are often associated, and may have developed from dolomitic material. Accessories include apatite, partly euhedral sphene, zircon, zoisite and ferruginous opaques. These minerals are often totally enclosed in quartz. The sphene is particularly abundant, and when enclosed by the amphibole it forms a pleochroic halo in the latter. The presence of sphene indicates a partly calcareous matrix and defines the facies (sphene does not occur in the granulite facies).

P934/59. *Location*: Half mile NW Grampus Ruins, Manunda Station. *Collected by*: R. C. Mirams. *Examined by*: M. J. Bucknell.

Composition: Quartz and tourmaline, with lesser orthoclase and minor rutile sphene.

Texture: Quartz is very coarse, and has partly replaced the orthoclase. Both minerals have been partly replaced by tourmaline. This mineral is usually colourless dravite, but some crystals are zoned, with a centre pleochroic from pale pink-olive green. It occurs in patches of 2-200 micron grains, enclosing scattered residuals of quartz and felspar.

Golden-yellow rutile forms large crystals enclosed by quartz.

Classification: Metasomatic. The boron concentrated here may also be responsible for the authigenic tourmaline occurring elsewhere.

P601/60. *Location*: Gorge Well Section, Lilydale Station. *Collected by*: R. C. Mirams. *Examined by*: R. F. La Ganza and R. A. Both.

The constituents of this rock are tremolite-actinolite 60 p.c., quartz 20 p.c., garnet (almandine) 10 p.c., and epizoisite 10 p.c.

A marked lineation is present with numerous augen representing porphyroblasts of epizoisite and garnet in incipient growth. The quartz commonly forms groups of small, irregular grains.

The rock has been raised to the amphibolite facies and probably represents a former basic igneous rock.

P602/60. *Location*: Gorge Well Section, Lilydale Station. *Collected by*: R. C. Mirams. *Examined by*: R. F. La Ganza and R. A. Both.

The constituents of this rock are quartz 40 p.c., tremolite 30 p.c., plagioclase 20 p.c., biotite 10 p.c., and minor epidote.

The rock is essentially equigranular with an average grain size of 75 microns, the grains having irregular shapes. A weak lineation is evident.

The rock in its present state probably represents an impure calcareous sandstone raised by metamorphism to the amphibolite facies.

P603/60. *Location*: Gorge Well Section, Lilydale Station. *Collected by*: R. C. Mirams. *Examined by*: R. F. La Ganza and R. A. Both.

The constituents of this rock are augite 40 p.c., quartz 30 p.c., plagioclase 20 p.c., potash felspar 10 p.c., and minor epidote and uralite.

A marked banded texture is displayed with bands of fine-grained (75 microns) augite alternating with much coarser bands of quartz and felspar. The plagioclase is probably labradorite and has altered to epidote in some instances. Augite displays alteration to uralite.

The rock is a pyroxene gneiss representing the granulite facies.

P604/60. *Location*: Gorge Well Section, Lilydale Station. *Collected by*: R. C. Mirams. *Examined by*: R. F. La Ganza and R. A. Both.

The constituents of this rock are quartz 40 p.c., clinopyroxene 35 p.c., labradorite 25 p.c., sphene 5 p.c., and minor hornblende.

The rock is essentially an aggregate of irregular grains showing no apparent lineation. The average grain size of the quartz is 600 microns and that of the others 150 microns. The plagioclase lacks twinning and the quartz shows no signs of stress. Partial replacement of clinopyroxene by hornblende is evident.

The rock is indicative of the pyroxene-hornfels facies and was probably a rather basic rock which has been silicified at a temperature of 600-700° C.

P605/60. *Location*: Gorge Well Section, Lilydale Station. *Collected by*: R. C. Mirams. *Examined by*: R. F. La Ganza and R. A. Both.

The constituents of this rock are quartz 45 p.c., oliogoclase 40 p.c., clinopyroxene 15 p.c., and minor hornblende and sphene.

The grains form an irregular aggregate, no banding or lineation being displayed. The quartz varies in grain size from 50 to 800 microns. The oligoclase rarely displays twinning and commonly forms grains approximately 600 microns in diameter which are, more often than not, partially silicified. Clinopyroxene forms grains 50-600 microns in diameter and appears altered locally to hornblende.

The rock probably represents an impure acid igneous rock or a high-grade metamorphic rock.

METAMORPHIC ROCK SPECIMENS

P604/59. *Location*: Half mile SW of Gap East Well, Netley Gap Station. *Collected by*: R. C. Mirams. *Examined by*: M. J. Bucknell.

Composition:

Quartz, 30-60 microns	45 p.c.
Biotite, interstitial	30 p.c.
Chlorite, interstitial	20 p.c.
Oxides, 20-100 microns	2-3 p.c.
Tourmaline (blue-green)	traces
Apatite	

Texture: The rock has a weak schistosity at a low angle to the original bedding. This gives a scalloped surface to the hand specimen (compare M.U. 15, p. 10) (Report No. NPNC 155/59.) Quartz is elongated parallel to the schistosity.

The distribution of biotite and chlorite is patchy, with curved contacts between parts rich in biotite, and adjacent parts with no biotite but some chlorite.

The oxides are usually disseminated, but locally occur in rows at an angle to the schistosity (i.e., along the original bedding planes). The grains are often euhedral, and good octahedral outlines can be seen, indicating magnetite.

Classification: Semi-pelitic siltstone. Metamorphic changes are due mainly to pressure (greenschist facies).

P605/59. *Location*: Half mile SW of Gap East Well, Netley Gap Station. *Collected by*: R. C. Mirams. *Examined by*: M. J. Bucknell.

Composition:

Coarse quartz, 200-800 microns	3 p.c.
Fine quartz, 30-200 microns	55 p.c.
Biotite	20 p.c.
Hornblende (blue), 30-150 microns	20 p.c.
Albite, 30-100 microns	3 p.c.

Texture: The quartz grains above 200 microns vary from round to angular, and are all stressed. Biotite and hornblende (probably sodic) are mainly disseminated. However, there are lenticles containing an aggregate of either biotite or hornblende, and much of the felspar is associated with these.

Classification: A semi-pelitic siltstone or sandstone originally. Metamorphism is to a higher temperature (low amphibolite facies) than in P604/59, but stress is still important. The lenticles may be due to a "basic front" associated with the granite.

DESCRIPTION OF TWO NEW AUSTRALIAN SMARIDIDAE (ACARINA), WITH REMARKS ON CHAETOTAXY AND GEOGRAPHICAL DISTRIBUTION

BY R. V. SOUTHCOTT

Summary

Two new Australian species of Smarididae (Acarina) are described, each from the adult and nymphal instars. These are Smarts cooperi, n. sp., from South Australia and Western Australia, and Fessonia taylori, n. sp., from New South Wales, thus increasing the known Australian fauna of each genus to two species. Distinguishing characters are given and some additional features of the chaetotaxy of the Smarididae described. A coding system of general applicability for the chaetotaxy of these and other mites is given. Comment is made upon the distribution of Smaris in Australia and elsewhere.

DESCRIPTION OF TWO NEW AUSTRALIAN SMARIDIDAE (ACARINA), WITH REMARKS ON CHAETOTAXY AND GEOGRAPHICAL DISTRIBUTION

by R. V. Southcott

(Read 10 August 1961)

SUMMARY

Two new Australian species of Smarididae (Acarina) are described, each from the adult and nymphal instars. These are *Smaris cooperi*, n. sp., from South Australia and Western Australia, and *Fessonia taylori*, n. sp., from New South Wales, thus increasing the known Australian fauna of each genus to two species. Distinguishing characters are given and some additional features of the chaetotaxy of the Smarididae described.

A coding system of general applicability for the chaetotaxy of these and other mites is given.

Comment is made upon the distribution of *Smaris* in Australia and elsewhere.

INTRODUCTION

Previously the genera *Smaris* Latreille, 1796, and *Fessonia* Heyden, 1826, have each contained one known Australian species, these being *Smaris prominens* (Banks, 1916) and *Fessonia australiensis* Southcott, 1946 (Womersley and Southcott (1941), Southcott (1946a, 1960)). In the present paper a further species of each genus will be described from Australia, these being *Smaris cooperi*, n. sp. from South Australia and Western Australia, and *Fessonia taylori*, n. sp. from New South Wales. The generic terms will be used in the sense of the author's (1961b) revision of the Erythraeoidea, and the descriptive terms will be as used there and in the author's study (1962) of the North American and other Smarididae.

DESCRIPTION OF A NEW SPECIES OF *SMARIS*

Smaris cooperi n. sp.

Figs. 1-6

Description of adult female (Figs. 1-5) (from the holotype ACA1733). Colour in life reddish. Animal of normal smaridid shape, with a slender nasus and with the idiosoma provided with sclerotized plates. Idiosoma 990μ long to tip of nasus, by 540μ wide where widest, at the "shoulders" at about the level of the midsensillary point of the crista.

Anterior dorsal scutum as figured (Figs. 1, 2, 3), with narrow anterior projection on to the nasus, and circular posterior part, the whole scutum thus pyriform in outline, 515μ long by 335μ wide, enclosing the eyes and sensillary areas. The anterior dorsal scutum has a slight ocular projection near the eyes on each side.

Eyes 2 + 2, each lateral pair arising from a lightly sclerotized ocular boss; anterior eye the larger, about 38μ across, directed anterolaterally, the posterior about 26μ across, directed posterolaterally. The ocular boss carries 7-8 normal dorsal idiosomalae (scobalae) and is placed near the edge of the scutum as figured (Fig. 2).

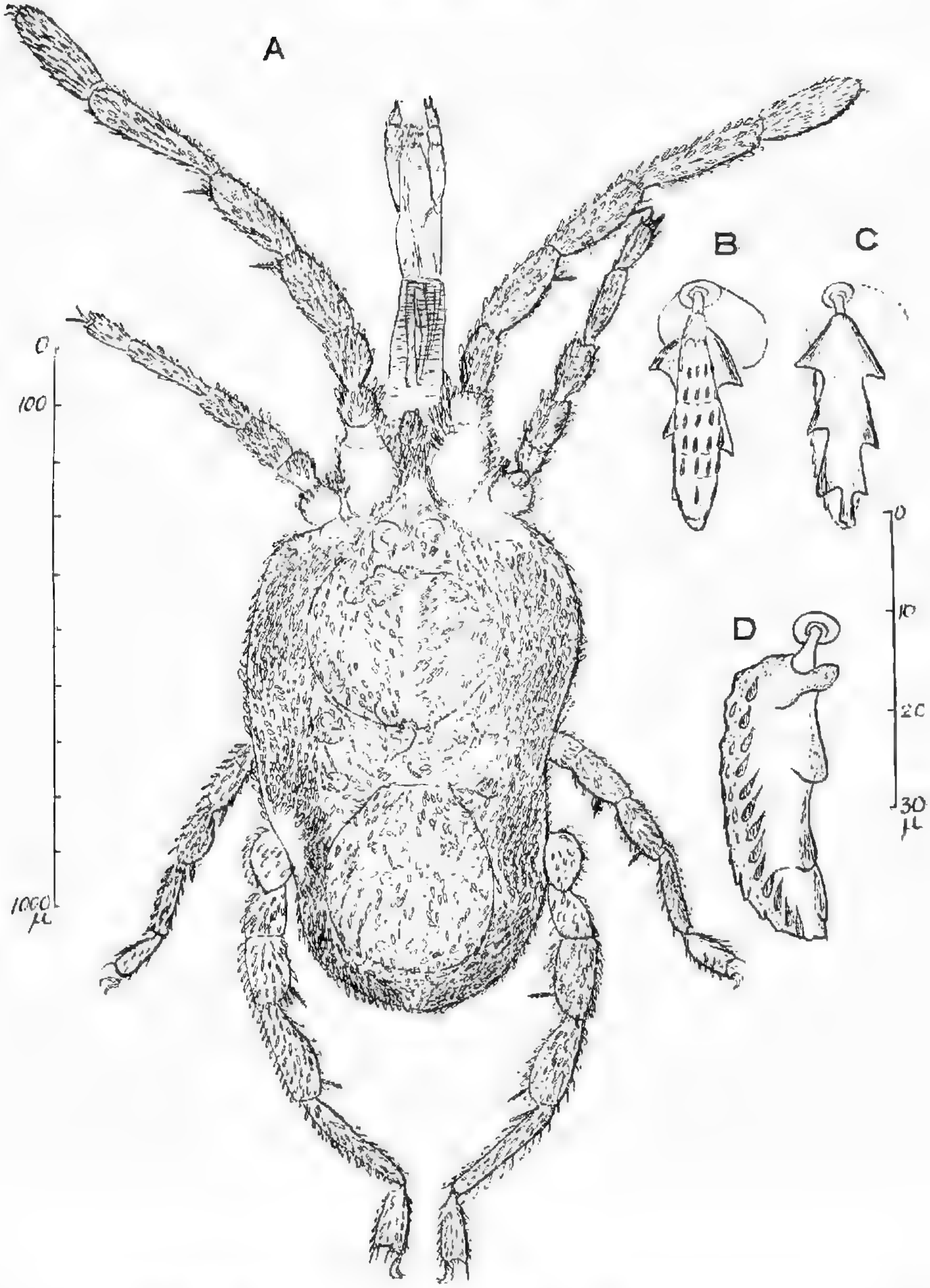

Fig. 1. *Smaris cooperi*, n. sp. Adult female (holotype). A, entire, dorsal view, to scale on left. B-D, views of dorsal idiosomalae, to scale on right; B, from above; C, same seta from below; D, lateral view of a large seta from near posterior pole of idiosoma.

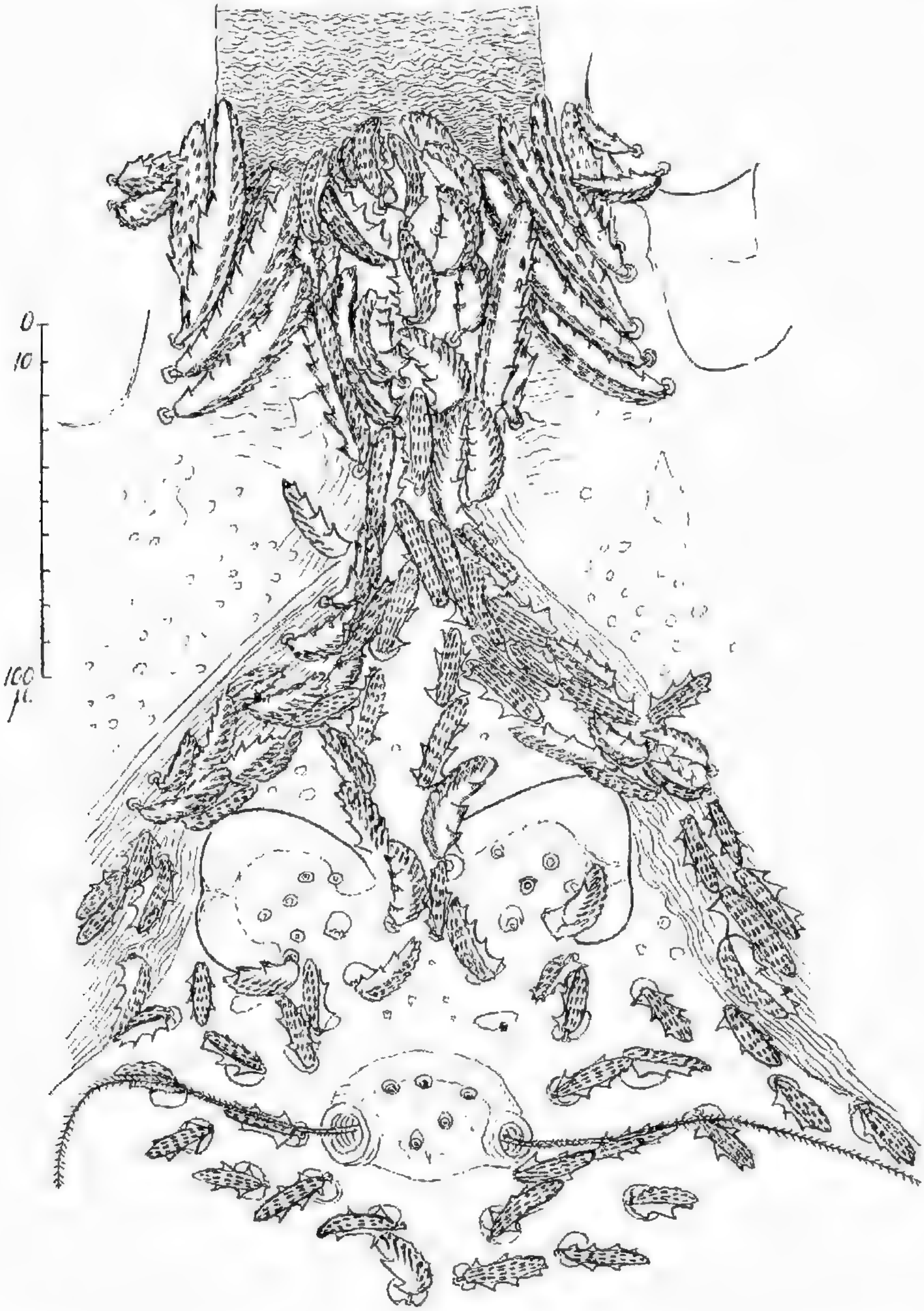

Fig. 2. *Smaris cooperi*, n. sp. Adult female (holotype). Dorsal view of propodosoma and adjacent structures.

Anterior sensillary boss lightly sclerotized, with 5 scobalae (ACA1733, 1734). Anterior sensillae slender, tapering, ciliated throughout, the ciliations small in proximal third, more distally the ciliations are longer, but over the distal half remain fairly constant in length and distribution. Posterior sensillary boss lightly sclerotized, without scobalae; posterior scutal sensillae similar

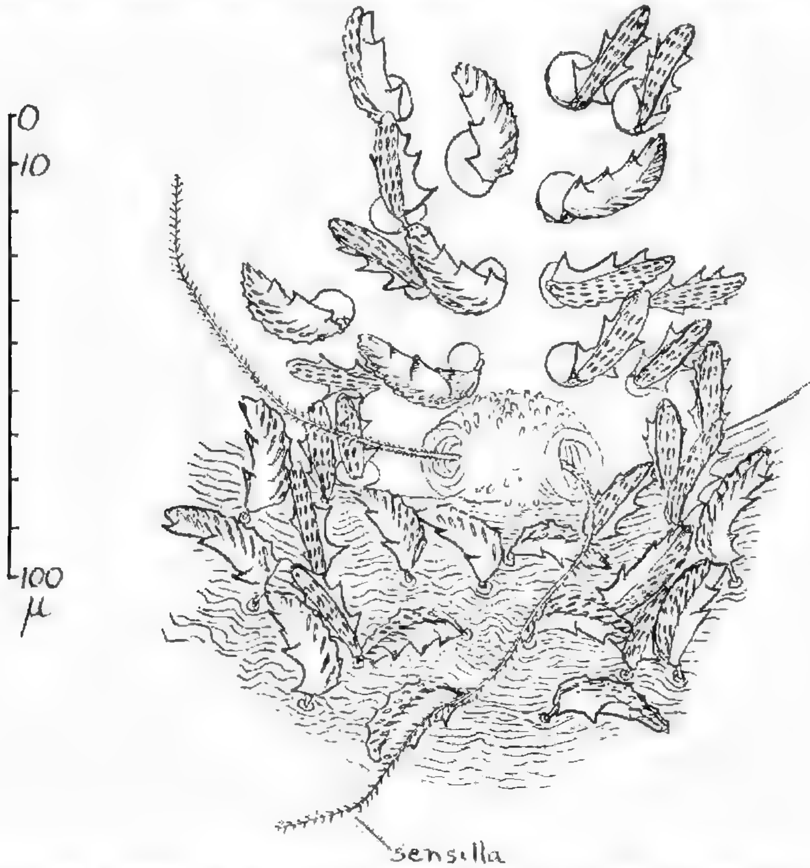

Fig. 3. *Smaris cooperi*, n. sp. Adult female (holotype). Posterior sensillary area of anterior dorsal scutum and adjacent structures.

to anterior sensillae. Scobalae of anterior dorsal scutum arise from the side of a circular or oval pit. In places among these are much smaller pits. Between the anterior and posterior sensillae there is a narrow strip of scutum devoid of seta-pits, and thus a crista is outlined upon the scutum.

The standard data of the type and paratype specimens are as follows:

	ASens	PSens	SBa	SBp	ISD	DS
Holotype ACA1733 (S. Aust.)	104	104	41	24	235	22-30
Paratype ACA1734 (S. Aust.)	ca. 100	ca. 115	44	25	280	20-32
Paratype ACA1737 (W. Aust.)	83	97	51	23	238	20-32

Posterior dorsal scutum of female large, elliptical, anterior margin a little flattened, 266μ long by 230μ wide.

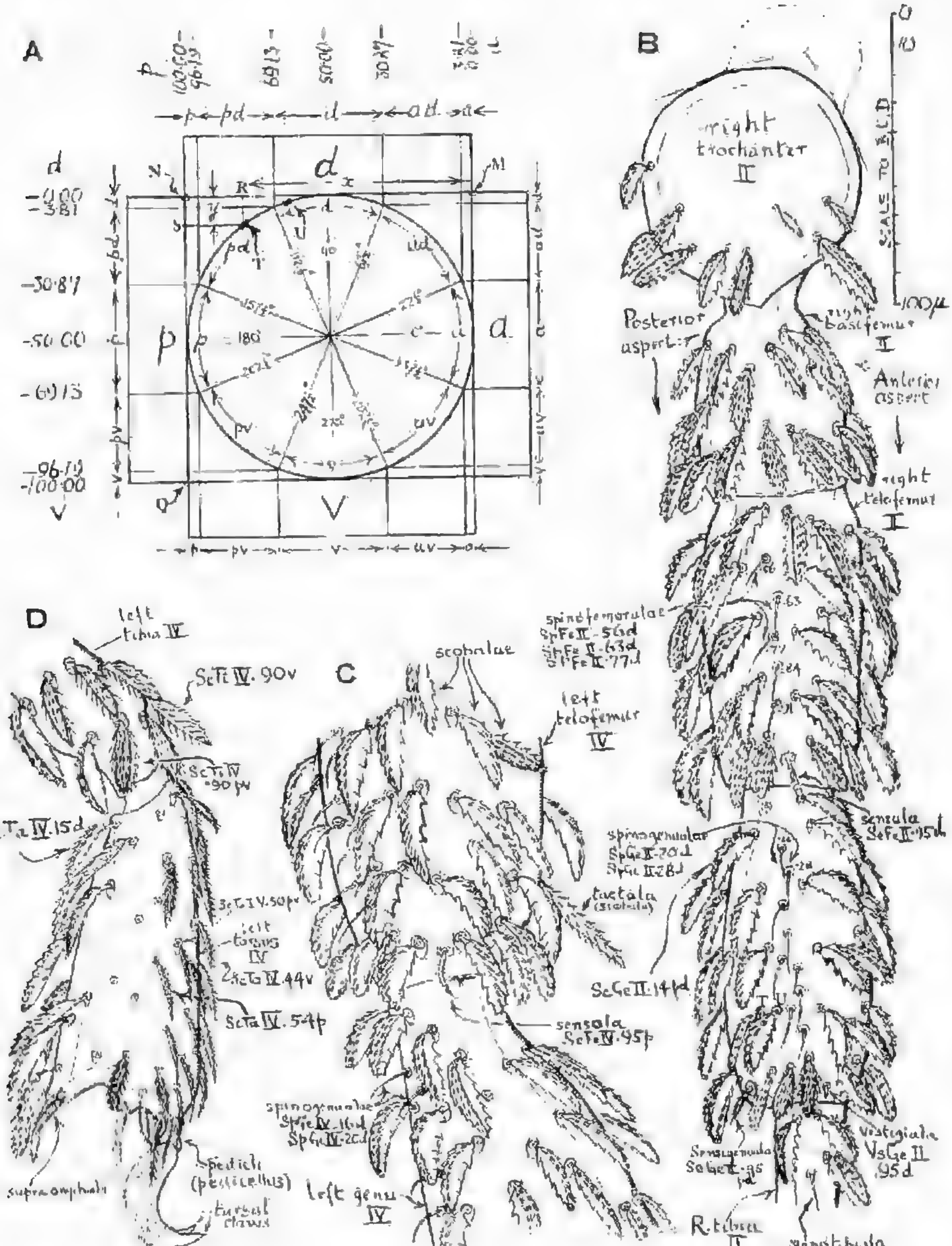

Fig. 4. A, diagram of transverse section of arthropod limb to show conventions used in the system of coding setae introduced in this paper. The limb has anterior, posterior, dorsal and ventral surfaces (a, p, d, v respectively). The circle represents the circumference of the section and is divided into 8 equal segments, a, ad, d, pd, ... respectively, and the projections of these upon vertical and horizontal tangential planes are shown. T and U represent the positions of setae T and U in Fig. 4 B. See text for further explanation. B-D, *Smaris cooperi*, n. sp. Adult female (holotype), parts of various limbs: B, proximal part of right leg II, from above; C, posterior surface of left leg IV, showing part of femur and genu; D, tip of left leg IV, posterior aspect, showing tarsus IV and part of tibia IV. Figs. B-D show the application of the chaetotaxic coding system, explained further in text.

Dorsal idiosomal setae (scobalae) have a dorsal flange or tectum setae that is fusiform or clavate and which has about 10 transverse rows of spicules, these tending also to form into longitudinal columns. The transverse rows have up to 5 or 6 spicules. The carinal flange expands into a wide plate, each lateral edge with 3-4 large serrations (see Fig. 1 B, C, D). The dorsal setae vary considerably in size. The posterior setae are large, as are also some near the ASens and anterior to the PSens. The scutal scobalae are mostly smaller than those from the striate cuticle (i.e. the non-scutal dorsal idiosomalae). Setae from the upper surface of coxae I are to 60μ long.

Venter normal for genus, external genitalia and anus normal. The more peripheral ventralae similar to dorsalae, but smaller and proportionally less elongate; the more central ventralae have the carinal serrations lengthened so that the setae tend to resemble the typical bushy smaridid central ventralae with long ciliations. Specialized scobalae of anus and external genitalia are like fir-cones with pointed bracts; setae of labial edges of genitalia ("labialae") pointed, slender, slightly ciliated with adnate ciliations, and many of the labialae are angled, resembling an angled dagger.

Legs normal: lengths (including trochanter to tips of tarsal claws): I 980μ, II 590μ, III 525μ, IV 850μ. Tarsus I 205μ long by 64μ across, tibia I 230μ long. Tarsus IV 119μ long by 50μ high, tibia IV 209μ, 217μ long. (Tarsal lengths exclusive of claws and pedicle.) Leg setae as figured, the distribution appearing normal (see Figs. 1, 4 B-D). Pedoscobalae similar to dorsal idiosomalae, but distally along the legs these setae become more elongate and pointed. Each pedoscobala has an ovoid depression surrounding the seta-base (annulus), with the acuter end pointing distally along the leg; this is a normal feature in adult, nymphal and larval Erythraeoidea, and is illustrated in Fig. 4 B, C for *S. cooperi* as well as in Fig. 7 J for *Fessonia taylori*. A vestigiala is present distally upon tibia II (see Fig. 4 B) (coding VsGeII.95d*).

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* This system of coding here introduced, is based upon the classification of setae elaborated by the author (1961b) in his review of the Erythraeoidea, including chaetotaxy and other aspects. As used in this example, Vs = vestigiala, Ge = genu, II = leg II, ·95 indicates that this seta is found on a coordinate 95/100 along the length of the segment concerned, measuring distally between the two chitinous end-points, and d = dorsal. It is proposed to use similarly the following: Sc = scobala, Se = sensala, So = solenoidala, Ss = sensilla, St = seta of undefined type, Si = sinuala, Sx = supracoxala, Su = supraonychiala, Ta = tactala (scobala), Fa = famulus (famala), Cp = companala, for various types of setae; I-IV to indicate the legs; Pa for the palp; Cx = coxa, Tr = trochanter, Fe = femur, Ti = tibia, Ta = tarsus, for the limb segments; a = anterior, ad = anterodorsal, av = anteroventral, d = dorsal, p = posterior, pd = posterodorsal, pv = posteroventral, v = ventral, for position around the circumference of a transverse section of a limb segment; L = left, R = right. These terms and concepts are explained by the author (1961b) (except for sinuala, which is introduced in another paper (1961a)) where the subject is treated from an historical viewpoint. The system and code incorporate proposals and terms from other authors but the system of lettering proposed here is new, and may use letters in a different way from those used by other authors. It is hoped that this system of coding will provide a method of general availability among the Acarina, and will be simple to use. Various other examples of its use will be made in the present paper, particularly in Fig. 4 B-D.

Some further comment is necessary upon the use of the circumferential positions of setae. The circumference of a transverse section of a limb segment is treated as a circle, and divided into 8 segments, a, ad, d . . . (as shown in Fig. 4 A), each subtending an angle of 45° at the centre. The projections of these segments upon tangential planes is shown there, thus MN indicating the dorsal tangential plane. In general it will be found that in the erythraeoid leg, as well as for many other Acarina, the code as given in the example above will specify a single seta. In certain circumstances, e.g. where more than one seta answers to the coding, then it may be necessary to introduce a further specification and code symbol. Thus the radial coordinate suggested by the author (1961b) could be used, or some equivalent of it. Thus if the two setae labelled T and U upon genu II in Fig. 4 B were both coded ScGeII.71pd (actually U is coded ScGeII.71d, but this example

Sensalae of the legs: typical tromibiform-type spinalae are present upon the dorsal aspects of the telofemora, genua and tibiae (Fig. 4 B, C). The tarsi carry the supraonychialae and other modified setae as figured (Fig. 4 D). In addition to the normal spinalae the telofemur carries posterodorsally at its distal end a ciliated sensory seta which is presumably a modified spinala or "eupathid". As its affinities are uncertain, it is here called, non-committally, a "sensifemorala" (Fig. 4 B, code SeFeII.95d). Similar setae upon genu II and femur IV are shown in Figs 4 B, C respectively.

Gnathosoma normal for family, as figured (Fig. 5). Palpal scobalae slender, pointed, ciliated, tectum setae not expanded.

Description of Nymph (Fig. 6 A-D) (from ACA1738, supplemented from ACA1739). Colour not recorded. Animal of normal nymphal smaridid build, with a short slender nasus and moderately sclerotized plates. Idiosoma 710μ long by 515μ wide (the specimen is somewhat swollen in the Hoyer's chloral hydrate medium used as a mountant).

Anterior dorsal scutum as figured, somewhat quadrangular with anterior projection on to the nasus, and with rounded angles, 310μ long by 215μ wide, enclosing the eyes and sensillary areas. There is a slight ocular projection of the scutum edge near the eye-bosses.

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is given since there is no suitable pair of setae in Fig. 4 to illustrate this principle) then a further specification would be necessary. The positions of setae T and U are represented diagrammatically in Fig. 4 A. Using seta T as an example, since calculating the radial coordinate from a slide specimen would require determining, e.g. the proportion MR/MN, it would be simpler to use such a proportion as the further coordinate (the proportion being specified as either across the a-p diameter of the section, or across the d-v diameter). Thus, if a = 0 and p = 1·00, we have for setae T and U the following coding:

T SeGeII.71pd(.76p),
U SeGeII.71d(.65p),

where the coordinates in brackets refer to the projection along MN (or NO). It will be noted the code letter p is required within the brackets, since if the leg were lying flexed on its side on the slide, one would have to use the d-v projection.

If (e.g in the case of seta T) we call the a-p distance x (a = 0, p = 1.00) (MR in Fig. 4 A) and the d-v distance (NS) y (d = 0, v = 1.00), we have, for a circular cross-section:

$$(x - \tfrac{1}{2})^2 + (\tfrac{1}{2} - y)^2 = (\tfrac{1}{2})^2.$$

Hence for $x = .76$, $y = .0720$.
and for $x = .65$, $y = .0231$.
Thus if the d-v projection is used the same setae T and U could be coded thus:

T SeGeII.71pd(.07v),
U SeGeII.71d(.02v)

(In the case where the limb transverse sections are markedly non-circular it would in general be best to specify coordinates in whatever is the more usual attitude for legs to assume on a slide. In the Smarididae there is a tendency for a leg to appear vertically compressed (i.e. height greater than width), at least in some segments, and thus it may be more convenient to use the d-v projection, particularly with detached legs on a slide.)

A similar convention can be used to code the type and position for the idiosomal setae. Thus, scobala W in Fig. 6 A may be coded as LScDo.76w(.66p). Here L = left of the median sagittal plane, Do = dorsal, .76w means that WK/DK = 0.76 (WK = z, DK = w), .66p means that AK/AP = 0.66 (AK = x, AP = p) (see Fig. 6 E). This coding could be abbreviated to LDo(.76, .66). A similar coding could be used for the ventral setae (Ve = ventral). It will be noted that in this convention the distance from the median sagittal plane is coded before the a-p coordinate. If the animal is regarded as having the a-p length as in a N-S direction, then D-E runs in a W-E direction. The code proposed thus follows the ordinary grid convention of placing "eastings" before "northings". It will be noted also that the same applies with the system proposed for the leg coordinates.

This idiosomal coding system is likely to be of most use where setae are numerous and are not capable of being specified clearly by relation to other structures, as happens with the idiosomalae of many of the Erythraeoidea and Trombidioidea, particularly in the 8-legged stages. To what extent these coordinates change during the duration of that instar from growth due to feeding is not clearly known, and will require further study.

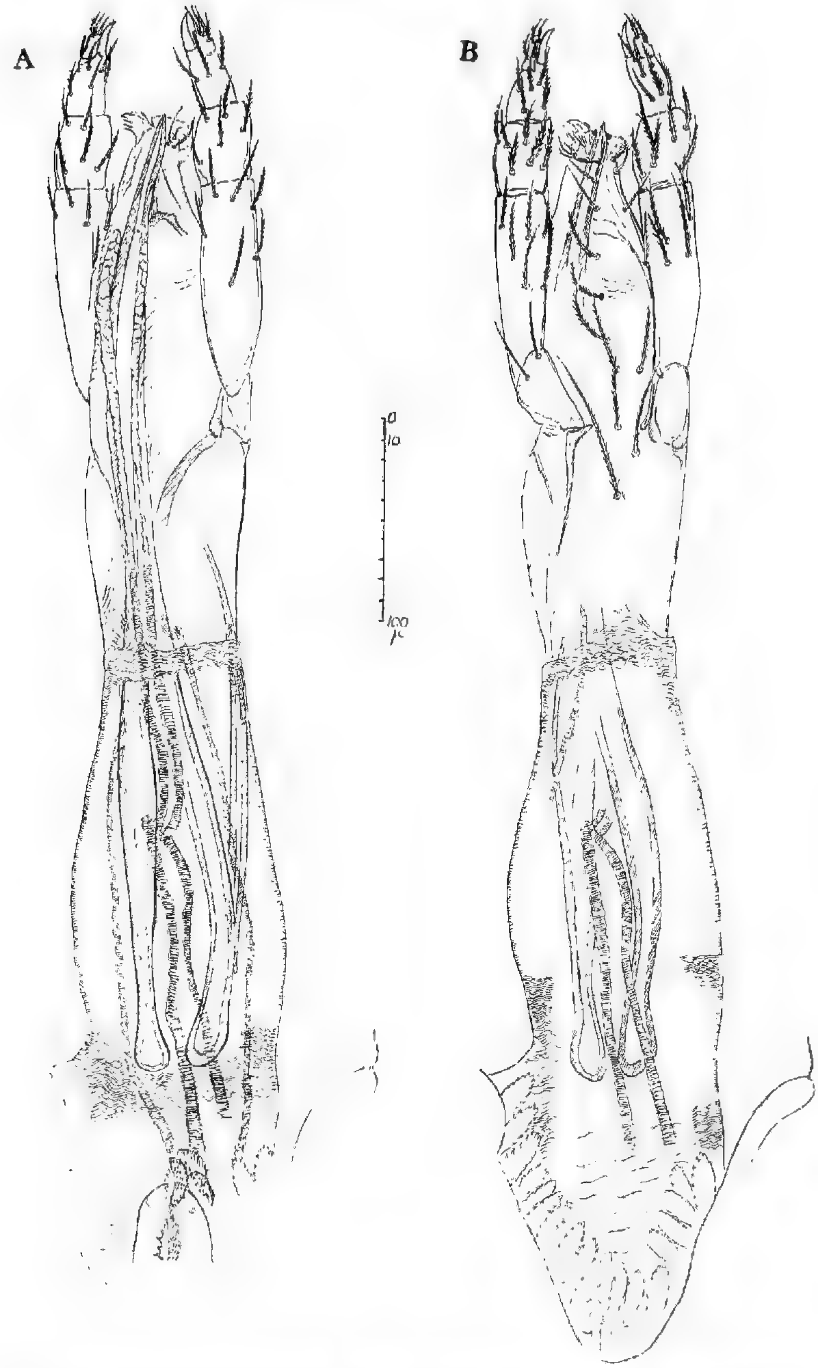

Fig. 5. *Smaris cooperi*, n. sp. Adult female (holotype). Gnathosoma, fully extended, showing details of internal structure. A, from above; B, from below.

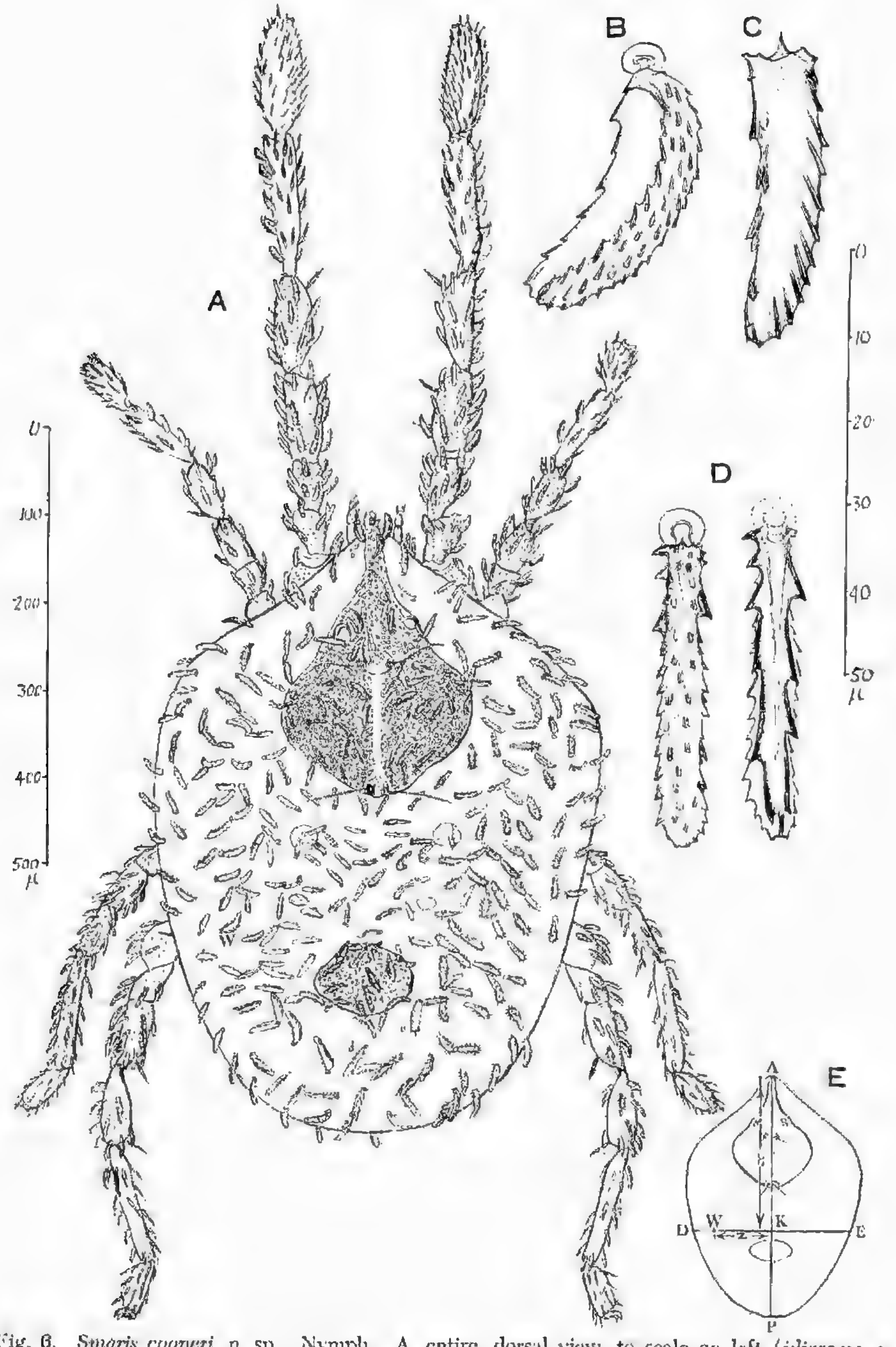

Fig. 6. *Smaris cooperi*, n. sp. Nymph. A, entire, dorsal view, to scale on left (idiosoma a little swollen by the mountant); b, c, d indicate the setae illustrated in Fig. 6 B, C, D respectively; W indicates a seta used to illustrate a system of coordinates and coding explained in the text and in Fig. 6 E. B-D, dorsal idiosomal scobalae, to scale on right: B, lateral view of a seta on the nasus; C, lateral view of a seta near posterior dorsal scutum; D, dorsal and ventral aspects (i.e. tectal and carinal) of a seta near the posterior dorsal scutum. E, diagram to explain convention of coding proposed for idiosomal setae (see text); W indicates seta W in Fig. 6 A.

Eyes 2 + 2, as described in adult; anterior 27μ across, posterior 20μ across. Ocular boss carries two normal dorsal scobalae.

Anterior sensillary boss lightly sclerotized, anterior sensillae as described for adult. Posterior sensillary boss lightly sclerotized, without scobalae, posterior sensillae as described for adult.

The anterior dorsal scutum has a reticular pattern made of small polygonal pits, except between the sensillary areas, and which thereby indicates a crista within the scutum. The scobalae of the anterior dorsal scutum originate from the sides of rather large circular or rounded-polygonal pits set among the smaller polygonal pits; the small pits are devoid of setae. The scutal scobalae are similar to the other dorsal idiosomal scobalae.

The standard data of the specimen (ACA1738) are:

ASens	PSens	SBa	SBp	ISD	DS
75	90	28	16	141	20-42

Posterior dorsal scutum small, lying transversely at junction of podosoma and opisthosoma, length 85μ, width 108μ, with reticular patterning from polygonal pits as in the anterior dorsal scutum, but without any unpatterned median strip, and in addition with normal dorsal scobalae arising from larger rounded pits as in the anterior scutum.

Dorsal idiosomal setae (scobalae) resemble those of adult but are less chitinized, the tectum setae (dorsal flange of seta) almost parallel-sided, slightly clavate and distally blunted, the spicules tending to be more irregularly distributed. The carinal flange is narrower than in the adult, parallel-sided but with 5-6 coarse serrations which project only a little beyond the tectum setae (Fig. 6 B-D). Idiosomalae fairly uniform in size over the dorsum, this statement referring also to the scutal scobalae.

Venter (from ACA1738 and ACA1739): the anterior ventral plate which normally encloses the fused lateral coxa I and II of each side tends to be divided. Ventralae similar to those of adult. Urvulva normal for nymphal erythraeoid. Anus normal.

Legs normal, similar to adult. Leg lengths (including trochanter and to tips of tarsal claws): I 630μ, II 405μ, III 415μ, IV 530μ. Tarsus I 125μ long by 41μ high; tibia I 154μ long; tarsus IV 73μ long by 26μ high; tibia IV 145μ long (tarsal lengths exclusive of claws and pedicles). Leg setae similar to those of adult, the pattern of specialized sensalae being simpler.

Gnathosoma normal (not much extruded in the specimens available for study). Palpal scobalae slender, pointed, ciliated. Tibial claw falciform, simple, fairly strong.

Localities: South Australia, two specimens: (1) Muston, Kangaroo Island, in moss (site near the post office), 23 August 1943 (extracted subsequently by Berlese funnel), H. M. Cooper; register number ACA1733, holotype, in South Australian Museum collection. (2) Hindmarsh Falls, in moss, 13-25 October 1951 (extracted by Berlese funnel), R. V. Southcott; ACA1734, paratype, in author's collection.

Western Australia: Warren National Park, in moss in karri (*Eucalyptus diversicolor* F. v. M.) and undershrub forest, 1 mile west of Pemberton, 26 November 1960 (extracted subsequently by Berlese funnel), P. F. Aitken, 3 specimens: one adult female (register number ACA1737) and two nymphs (register numbers ACA1738 and ACA1739), in South Australian Museum collection. Mr. Aitken reports (personal communication, 1961) that the moss was growing on rotting fallen tree-trunks in the dense wet sclerophyll forest.

Nomenclature: The species is dedicated to its original collector, Mr. H. M. Cooper, a meticulous student of the aboriginal archeology and white exploration of South Australia, particularly of Kangaroo Island, who has collected biological specimens including Acarina in various South Australian localities.

Smaris cooperi n. sp. was referred to earlier by the present author as "an undescribed species from South Australia" (Southcott, 1961b, p. 424, line 11). This was written before the Western Australian specimens had been collected.

THE SYSTEMATICS OF *SMARIS* IN AUSTRALIA

Smaris cooperi n. sp. is a striking species, there being no species with a comparable dorsal idiosomal scobala that the writer has seen among Australian, North and Central American or African members of the genus he has studied, nor has been described from these regions or from Europe. The species may be distinguished from the other Australian species, *S. prominens* (Banks, 1916) thus:

A. Adults

Dorsal idiosomal setae ovoid, blunted terminally, with the edge of the carinal flange (i.e. ventral plate of these setae) of seta divided into about 6 teeth which do not project beyond edge of tectum setae (dorsal flange); dorsal idiosomal setae 15-20μ long ...... *S. prominens* (Banks)

Dorsal idiosomalae spindle-shaped or somewhat clavate, blunted terminally. Edge of carinal flange divided into 3 or 4 coarse serrations which project beyond edge of tectum setae. Dorsal setae more variable in size, 22-32μ long ...... *S. cooperi* n. sp.

B. Nymphs

Dorsal idiosomal setae lanceolate in outline, distally tapering smoothly to a point; carinal flange narrow-lanceolate with regular serrations; not projecting beyond edge of tectum setae. Dorsal setae 18-20μ long ...... *S. prominens* (Banks)

Dorsal idiosomal setae almost parallel-sided, the outline of the tectum setae slightly clavate, seta terminally blunted. Carinal flange broad, proximally as broad as tectum setae and with serrations, which in the proximal part of the seta project beyond the edge of the tectum setae. Dorsal setae 20-42μ long ...... *S. cooperi* n. sp.

REMARKS ON THE DISTRIBUTION OF THE GENUS *SMARIS* IN AUSTRALIA

The genus *Smaris* is widely distributed, occurring in Europe, South Africa, North and Central America, Australia and possibly South America (Southcott, 1961b, 1962). Previously the only species known from Australia has been *Smaris prominens* (Banks, 1916), which is widely distributed in the eastern half of Australia, it being recorded by Womersley and Southcott (1941) from New South Wales, Victoria and South Australia, and by Southcott (1960, p. 159) from north Queensland. The description of *Smaris cooperi* n. sp. thus increases the known Australian species to two.

At the present time *Smaris cooperi* is known from only three localities recorded above, these being Kangaroo Island in South Australia and Hindmarsh Falls on the adjacent mainland, and from the south-western corner of Western Australia. Hindmarsh Falls are near the southern end of the Mt. Lofty Ranges, toward Encounter Bay, and a gap of only 9 miles separates Kangaroo Island from the mainland. It is believed that this gap, Backstairs Passage, has originated during recent (Tertiary) geological times (Campana *et al.*, 1954; Glaessner and Parkin, 1958), and thus from a distributional viewpoint, Kangaroo Island

may be regarded as the continuation of the Mt. Lofty Ranges. However, it is probable that during the last glaciation at the end of the Pleistocene the sea-level sank with the world-wide regression and a land connection re-existed. With the passing of that epoch, about 10,000 years B.P., Kangaroo Island began again to be separated from the mainland (Tindale, 1957, p. 6).

Smaris prominens has not so far been recorded from Kangaroo Island, but so far collecting for this mite has been sporadic and not many records have been made for its localities of occurrence over the whole of Australia. The only locality which has been extensively surveyed for it is the Glen Osmond region near Adelaide, at the edge of the Mt. Lofty Ranges (see Womersley and Southcott, 1941). This species has also been recorded from the southern end of the Mt. Lofty Ranges, at Myponga and Encounter Bay (*loc. cit.*). Thus it is evident that, speaking broadly, the two species are sympatric at the southern end of the Mt. Lofty Ranges. Possibly wider distributions and more extensive overlapping will be revealed by further collecting.

Adults and nymphs of the Smarididae are predators on small insects and other arthropods, and are found in damp situations. Only a few larvae have been described, and of these only two species have been successfully correlated with the adult or nymphal stages by rearing in captivity, these species being *Smaris prominens* and *Sphaerotarsus leptopilus* Womersley and Southcott, 1941. *Smaris prominens* is the only species for which a suitable larval host is known; the larvae having been found to parasitize only small Psocoptera of the families Troctidae and Lepidopsocidae (see Womersley and Southcott (1941); Southcott (1960, 1961 a, b)). Neither the adults or nymphs of the Smarididae, nor the small Psocoptera so far found to be suitable larval hosts appear to be likely to be distributed by wind over any but short distances (many other insects have been examined for ectopararasitic larval Prostigmata by the author and others in Australia; no other hosts of larval Smarididae have been found). It must be admitted, however, that the possibility of wind distribution of smaridid mites cannot be entirely disregarded. Thus if a gravid female mite were in a suitable moist crack on a piece of bark on a eucalypt (such sites being favoured by these mites) it is by no means impossible that a piece of such bark could be stripped off and carried a considerable distance by a high wind, and the same could apply for the appropriate psocopteran hosts. Perhaps, however, too much should not be made of such a possibility, since if the transportation of fragments of eucalypts (such as are commonly the product of high winds, involving bark, leaves, blossoms and fruit) were of any great significance one might reasonably expect to find a very scattered distribution of eucalypt species, particularly those with small fruits and leaves and with a tall habit.

The sharp division between much of the flora and fauna of the western and eastern halves of the Australian continent is noteworthy, this applying not only to plants that are unlikely to be spread by wind-distribution and purely terrestrial animals, but applies also to e.g. a number of flying insects which would appear to be capable of being transported by winds over considerable distances, and for which a suitable food-supply is available. The works of Cross (1954, 1955, 1957), Crocker and Wood (1947), and Mackerras (1960) may be instanced as discussing the isolating mechanisms which have occurred with various of the Australian flora and fauna.

It is not at present known at what geological period the family Smarididae originated, or the genus *Smaris* or its species. Apart from a number of erythraeoid mites described from the Baltic amber (Oligocene) the only fossil erythraeoid is a larval mite from the Cretaceous amber of Canada, not ideal for description, and referred to briefly by Ewing (1937). The position of that

mite within the Erythraeoidea is not known; it is discussed by the author elsewhere (1961b). Some of the erythraeoid mites are ectoparasitic in the larval stage upon scorpions and other arachnids, but the majority are ectoparasites upon insects, the relations in some cases being suggestive of host-specificity, but not in others (see Southcott (1946b; 1961a, p. 174)).

The finding of a new species of *Smaris*, *S. cooperi*, in Western Australia and South Australia, indicates therefore a link between the faunas of those two regions. Little or no collecting has been done for Acarina over the arid zone between these regions. However, since Smarididae usually favour damp situations it would appear likely that the distribution of *S. cooperi* is discontinuous. Various examples could be quoted which suggest a link between the terrestrial faunas of the south-western corner of Western Australia and, for example, Kangaroo Island. The author is indebted to Mr. B. C. Cotton for pointing out that the Australian land snail genus *Bothriembryon* Pilsbry, 1894, has many species in the south-west of Western Australia, one extending across the Nullarbor Plain. The only other recorded distribution of that genus is (Cotton, 1957, pp. 123-4; 1959, p. 415 (personal communication, 1961)) of two species (*B. angasianus* Pfeiffer, 1864, on Eyre Peninsula, and *B. mastersi* Cox, 1867, on Eyre and Yorke Peninsulas, South Australia, *B. spenceri* Tate, 1894, from Central Australia, and a further species, *B. decresiensis* Cotton, 1940, from Kangaroo Island. Since these are dry-land forms, it would appear that the possible distribution of the genus by, for example, eggs or juveniles in mud on the feet of water-birds, is unlikely. Thus, *B. decresiensis* was originally found in dry situations upon the cliff-tops at Cape Cassini, Kangaroo Island, by its collector, Mr. H. M. Cooper (H. M. Cooper, personal communication, 1961) at the archeological camp-site recorded by Cooper (1960, p. 488).

Many other instances of links between the south-west of Western Australia and Kangaroo Island and the adjacent mainland of South Australia could be given. The position with regard to the flora is discussed in Crocker and Wood (1947). Earlier Wood (1930, p. 127) had concluded:

> "The flora of this Gulf Region [of South Australia] is composed almost equally of migrant species from the western and eastern centres of distribution in Australia, together with 82 endemic species out of a total of 657 species. The migration from the west was earlier than migration from the east; and the Southland, represented at present by Kangaroo Island and the sunklands of the gulfs, formed the chief means of passage through which the species of westerly origin passed. The migration of species from the eastern centre occurred chiefly after the separation of the Eyre Peninsula, and the gulfs have proved a barrier to westerly migration of these species."

Similarly, we may expect that many of the affinities of the terrestrial fauna of Kangaroo Island will be with the adjacent South Australian mainland and the eastern part of the Australian continent. To quote a single instance within the author's experience we may refer to the scorpion *Urodacus abruptus* Pocock, 1888. This species is recorded by Glauert (1925) and Southcott (1955) from Kangaroo Island, and on the Australian mainland extends from South Australia through Victoria and New South Wales. In south-western Australia the related *Urodacus novaehollandiae* Peters, 1861, replaces it, and this species extends as far east as Eucla (Glauert, 1925). This genus of scorpions (*Urodacus* Peters, 1861) consist of burrowing species only, and it may be accepted they have migrated solely along land-bridges. Even at the present time the possibility of long transportation of members of this genus by human agency in sand or soil appears very small.

It may be concluded that the distributions of *Smaris cooperi* and *Smaris prominens* in Australia, as far as they are at present known, are consistent with the viewpoint that *S. cooperi* could represent a species distributed from the south-western corner of the continent, and that *S. prominens* could represent a species distributed from a centre in the eastern half of the continent.

DESCRIPTION OF A NEW SPECIES OF *FESSONIA*

Fessonia taylori n. sp.

Figs. 7-10

Description of adult (probably female) (Figs. 7, 8) (from the holotype ACA1735). Colour in life reddish. Animal of normal smaridid shape and with a short nasus. Idiosoma 875μ long to tip of nasus by 485μ wide where widest.

Crista normal for genus, the anterior sensillae placed 235μ behind the nasus and just posterior to the eyes. The standard data are:

ASens	PSens	SBa	SBp	ISD	DS
65	62	26	26	198	20-41

Anterior sensillae slender, lightly ciliated throughout, ciliations longer in distal half of seta; posterior sensillae similar.

Eyes 2 + 2, the anterior the larger, 32μ across, posterior 24μ across and placed a little lateral to the anterior eye.

Dorsal idiosomalae (scobalae) brown, oval to clavate, blunted terminally, the longest setae being near the tip of the nasus or at the posterior pole of the idiosoma, and in these longest setae the widest point of the tectum setae is more than 3/4 along the length of the seta. Tectum setae with 4-6 columns of coarse serrations or spicules, these not linked to each other, with their two median columns usually regular, the other columns may be somewhat less regular. Spicules about 28-40 in number over tectum setae. Carinal flange narrow, its lateral edge with about 10-12 pointed strong ciliations.

Venter normal. The more peripheral ventral setae resemble the dorsal scobalae, but are rather simplified (Fig. 7 F, G) while the more central scobalae are the usual central ventral smaridid scobalae, with a compact centre from which arise long bushy ciliations (Fig. 7 H, I). Internal genitalia not clearly seen, but appear to be of female type.

Legs of normal size and shape for the genus. Leg lengths (including trochanter to tip of tarsal claws), I 1140μ, II 640μ, III 690μ, IV 1030μ. Tarsus I 185μ long by 68μ high, tibia I 255μ long, tarsus IV 140μ long by 41μ high, tibia IV 270μ long. (Tarsal lengths exclude claws and pedicle.) Tarsal claws normal, ciliated obliquely along their sides.

Setation of legs in general similar to that of *Smaris*. Pedoscobalae (except distally on tibiae and tarsi) similar to the idiosomalae, but tend to be more slender, as is usually the case in the Erythraeoidea. Also as is usual in the Erythraeoidea the annulus or seta-base of the pedoscobala is set in a small ovoid depression; a number of these are illustrated in Fig. 7 J. The middle segments of the legs carry normal Trombidiformes-type spinalae, as in *Smaris*. Several such are shown in Fig. 7 J on genu IV and tibia IV and one such is coded as SpGeIV.68d.* In addition to the spinalae the legs carry some ciliated sensalae. Some of these are illustrated in Fig. 7 J, two being shown upon telofemur IV and coded as SeFeIV.90d and SeFeIV.95d, and others upon the genu IV are shown, these latter being coded as SeGeIV.46pd, SeGeIV.48pd, SeGeIV.84pd and SeGeIV.94d.

* See the explanation of the coding system earlier in the present paper.

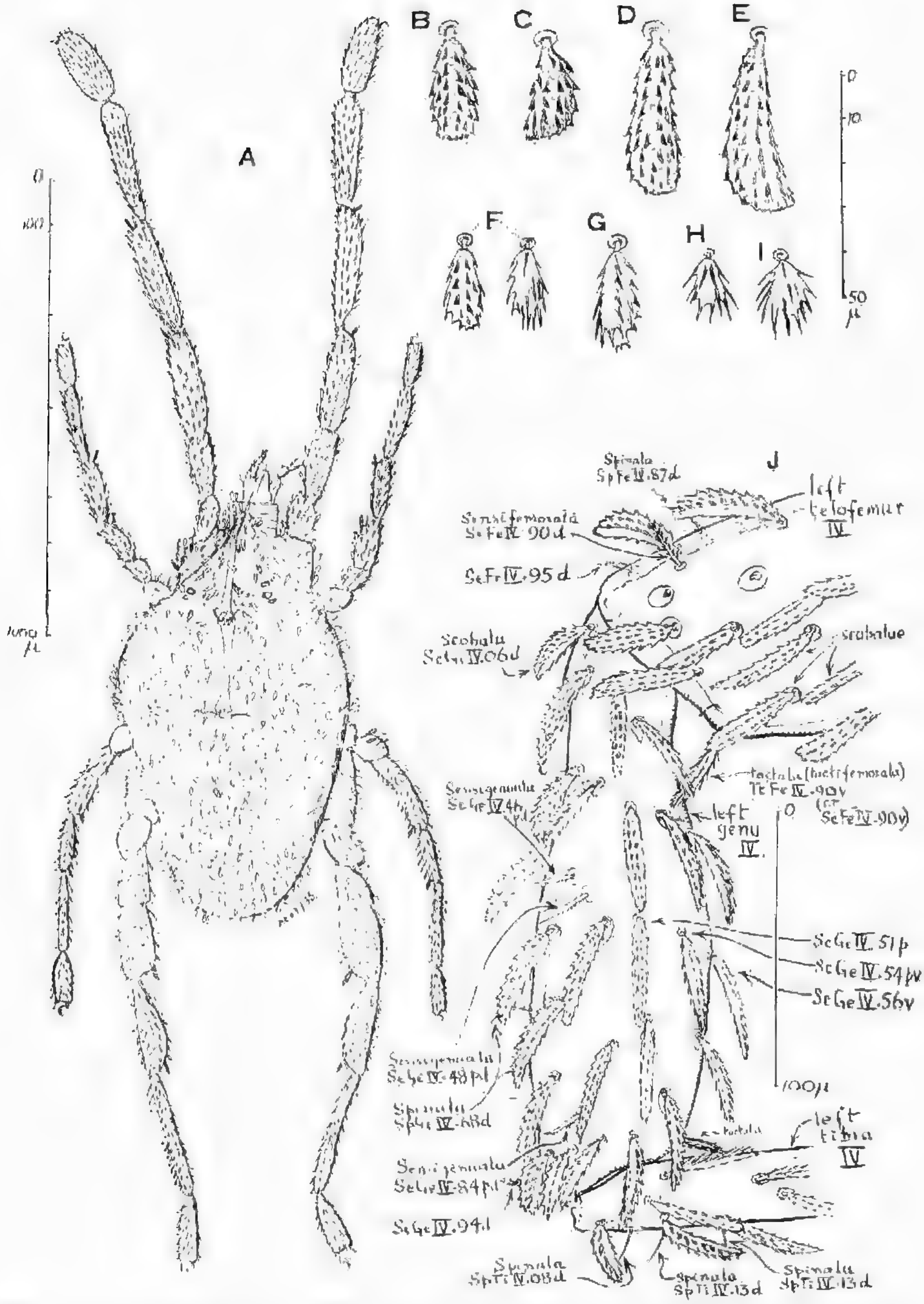

Fig. 7. *Fessonia taylori*, n. sp. Adult female (holotype). A, dorsal view, entire, to scale on left. B-I, various idiosomalae, to scale on right: B, C, dorsal idiosomalae near posterior sensillary area; D, E, posterior dorsal idiosomalae; F, a ventral idiosomala from tectal (left) and carinal (right) aspects; G, H, I, further ventral idiosomalae. J, posterior aspect of left genu IV, and part of telofemur IV and tibia IV, to show features of chaetotaxy (see in text for explanation of chaetotaxic coding) (to scale on right).

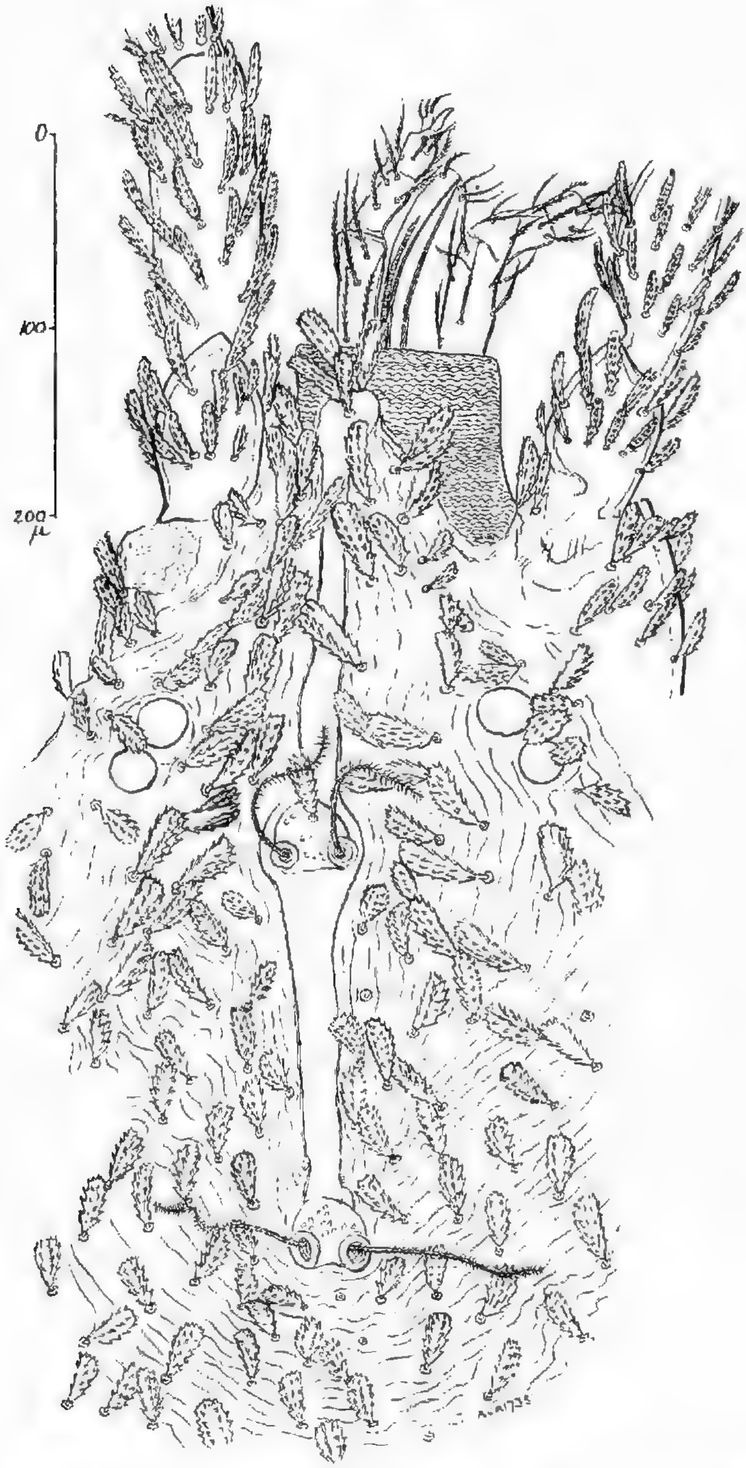

Fig. 8. *Fessonia taylori*, n. sp. Adult, holotype. Dorsal view of propodosoma showing crista, mouthparts, and adjacent structures.

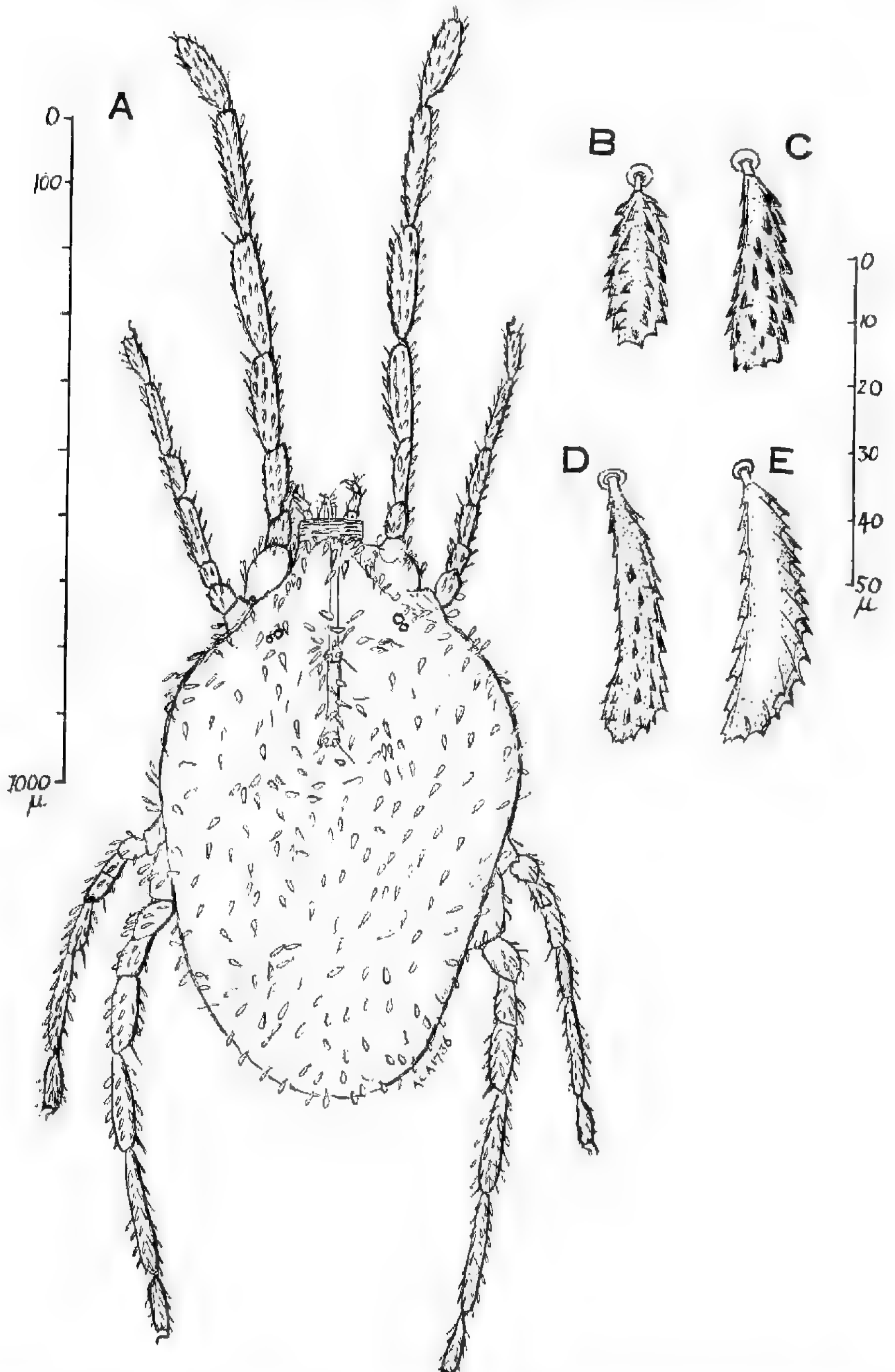

Fig. 9. *Fessonia taylori*, n. sp. Nymph. A, dorsal view, entire, to scale on left. B-E, dorsal idiosomal setae, to scale on right: B, C, two setae near posterior sensillary area; D, E, two setae near posterior pole of idiosoma.

Gnathosoma normal, as figured (Fig. 8). Palpal scobalae slender, ciliated.

Description of nymph (Figs. 9, 10) (from ACA1736). Colour in life reddish. Animal similar to adult but smaller and of more slender proportions. (The specimen studied has the idiosoma somewhat swollen by the polyvinyl alcohol-lactophenol mountant used.) Idiosoma 795μ long to tip of nasus, by 515μ wide. Crista normal for genus, ASens placed 160μ behind tip of nasus. Standard data are:

ASens	PSens	SBa	SBp	ISD	DS
56	83	16	20	121	18-42

Sensillae similar to adult.

Eyes similar to adult, anterior 22μ across, posterior 16μ across.

Dorsal idiosomal scobalae similar to those of adult, but tending to be more slender.

Venter appears normal, but not clearly seen in the preparation, which is dorsum uppermost.

Legs normal, of the usual slender nymphal smaridid proportions. Leg lengths (including trochanter to tip of tarsal claws) I 800μ, II 430μ, III 440μ, IV 700μ. Tarsus I 128μ long by 41μ high, tibia I 185μ long, tarsus IV 96μ long by 32μ high, tibia IV 185μ long (tarsus measured without claws or pedicle). Tarsal claws as for adult.

Gnathosoma normal, similar to adult. Palp and setation as described for adult.

Locality: National Park, Audley, New South Wales, 12 September, 1943, under leaf litter on damp soil in eucalypt forest along south bank of Kangaroo Creek, one adult (ACA1735) and one nymph (ACA1736) (R. V. Southcott).

Remarks on Nomenclature: This new species is dedicated to the late Mr. F. H. Taylor, 1886-1945, formerly Entomologist, School of Public Health and Tropical Medicine, Department of Health, Commonwealth of Australia, and University of Sydney, in gratitude for encouragement and many kindnesses.

THE SYSTEMATICS OF *FESSONIA* IN AUSTRALIA

Fessonia taylori n. sp. is quite distinct from the only other Australian *Fessonia* that has been described, *F. australiensis* Southcott, 1946, the latter known from the adult only. The adults of these two species may be separated by the following key:

Dorsal idiosomalae lanceolate-clavate, mostly with the widest point of the tectum setae about 2/3 along seta; with 6-8 well-defined regular columns of linked pointed spicules over the proximal 2/3 of the tectum, these columns then tending to break up more distally, being in the distal 1/3 of the tectum short, blunted and irregularly arranged, unlinked. Posterior dorsal scobalae 18-33μ long. Palpal scobalae elongate-lanceolate, ciliated .... *F. australiensis* Southcott, 1946.

Dorsal idiosomalae clavate, blunted, and in the more posterior setae, which are the more clavate, the widest point of the tectum setae is more than 3/4 along the seta. Tectum setae with 4-6 columns of coarse (serrate) spicules, not linked to each other, and of which the two median columns are usually regular, the more lateral columns tending to be less regular. Dorsal scobalae 20-41μ long. Palpal scobalae slender, ciliated .... *F. taylori* n. sp.

No attempt to key the nymphs will be made here as the nymph of *F. australiensis* has not as yet been observed from Australia.

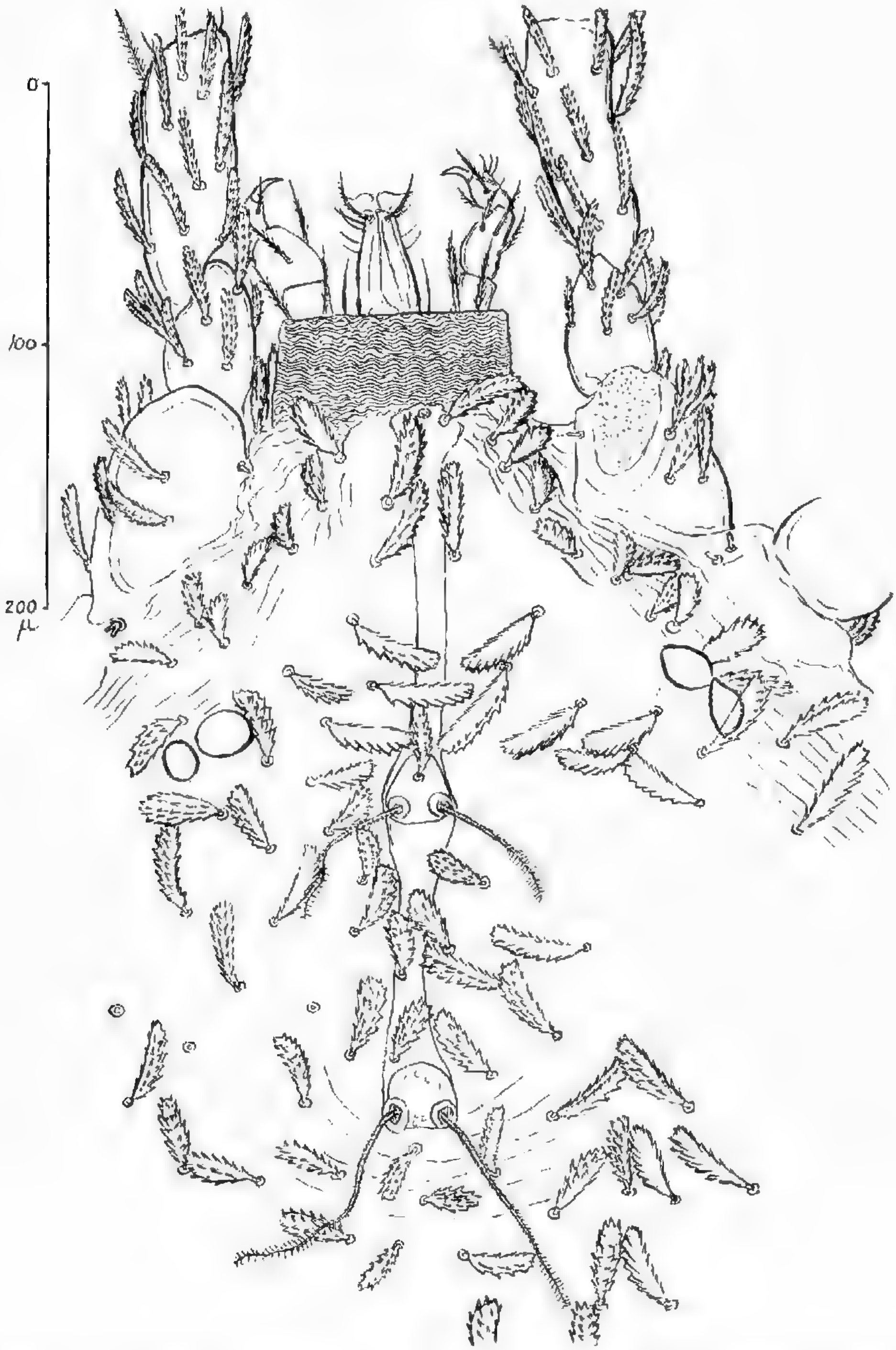

Fig. 10. *Fessonia taylori*, n. sp. Nymph. Dorsal view of propodosoma, showing crista, mouthparts, and adjacent structures.

A NOTE ON THE GEOGRAPHICAL DISTRIBUTION OF *FESSONIA AUSTRALIENSIS*

The type locality of *F. australiensis* was Mataranka, Northern Territory (see Southcott, 1946). The author has also in his collection an adult specimen of *F. australiensis* collected at Montalbion, Irvinebank, north Queensland, in litter and soil at base of *Eucalyptus* sp., at the edge of a large dam, 11 October, 1944 (R. V. Southcott). The author has also seen specimens of this species from India, Burma, China and Mexico from other collections, which will be recorded further elsewhere.

ACKNOWLEDGMENTS

In addition to the acknowledgments made in the text for material collected and information on field data, the author wishes to place on record his gratitude to the following, with whom he has discussed particularly the geographical factors in the distribution of the Australian fauna and flora: Mr. P. F. Aitken, Mr. H. M. Cooper, Mr. B. C. Cotton, Dr. B. Daily, Mr. G. F. Gross and Mr. F. J. Mitchell. The author wishes to thank also the Acting Director, South Australian Museum, for permission to study Museum material.

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* Contains a full bibliography of the family.

THE PLANT ECOLOGY OF THE MOUNT LOFTY RANGES, SOUTH AUSTRALIA
2. THE DISTRIBUTION OF *EUCALYPTUS ELAEOPHORA*

BY R. L. SPECHT, P. F. BROWNELL AND P. N. HEWITT

Summary

Eucalyptus elaeophora has a disjunct distribution pattern in south-eastern Australia, extending in a discontinuous arc in the highlands from northern New South Wales, through Victoria, into the Mount Lofty Ranges of South Australia and northward into the Flinders Ranges. The distribution of the species is examined in the Mount Lofty Ranges and discussed in relation to climatic and edaphic factors. In South Australia the species is found in the dry sclerophyll forest formation on very infertile soils developed from a wide variety of rocks – residual Tertiary laterites, Aldgate sandstone, Stonyfell Quartzite, Archaean schists and gneisses and even phyllites where the soil is highly leached. The climate of the area is of Mediterranean type with cool (mean July temperature 45° F.), wet winters alternating with hot (mean January temperature 65° F.), dry summers. Within this area *E. elaeophora* is widespread between the 27 and 36 inch isohyets. Small pockets are found in rainfall areas as low as 23 inches per annum, where infertile soil is found with a high water-retaining capacity. The species in South Australia appears to have reached its maximum southward distribution in the Mount Lofty Ranges. The ecological limits, thus defined for the Mount Lofty Ranges, are compared with those found for other areas within Australia. As the species extends from a region of winter rainfall1 to one where summer rain predominates, corrections had to be made. In all areas, foliage growth is greatest during summer; soil moisture stored from winter rains is utilized during this growth period; some 25 p.c. of the winter rainfall is lost by evapotranspiration before growth occurs. After this correction, the predominantly winter rainfall range (27 to 36 inches per annum) of the Mount Lofty Ranges is equivalent to that in the Monaro Region of New South Wales (19 to 26 inches per annum) where summer rainfall predominates. If these limits are correct, the species is unlikely to occur in wetter areas (as high as 48 inches per annurn) as recorded in the Dandenong Ranges, Victoria; this observation could be due to the difficulty of distinguishing E. *elaeophora* from *E. goniocalyx,* with which it hybridises. The distributions of the other eucalypts in the area are compared with those found to the south of the Torrens Gorge. The disjunct distribution of E. *baxteri* - Black Hill, Mount Gawler, Tanunda Creek - is of interest.

THE PLANT ECOLOGY OF THE MOUNT LOFTY RANGES, SOUTH AUSTRALIA

2. THE DISTRIBUTION OF *EUCALYPTUS ELAEOPHORA*

by R. L. SPECHT,[1] P. F. BROWNELL[2] AND P. N. HEWITT[3]

(Read 10 August 1961)

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In South Australia the species is found in the dry sclerophyll forest formation on very infertile soils developed from a wide variety of rocks – residual Tertiary laterites, Aldgate sandstone, Stonyfell Quartzite, Archaean schists and gneisses and even phyllites where the soil is highly leached. The climate of the area is of Mediterranean type with cool (mean July temperature 45° F.), wet winters alternating with hot (mean January temperature 65° F.), dry summers. Within this area *E. elaeophora* is widespread between the 27 and 36 inch isohyets. Small pockets are found in rainfall areas as low as 23 inches per annum, where infertile soil is found with a high water-retaining capacity. The species in South Australia appears to have reached its maximum southward distribution in the Mount Lofty Ranges.

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The distributions of the other eucalypts in the area are compared with those found to the south of the Torrens Gorge.

The disjunct distribution of *E. baxteri* – Black Hill, Mount Gawler, Tanunda Creek – is of interest.

INTRODUCTION

In the first paper in this series on the plant ecology of the Mount Lofty Ranges, Specht and Perry (1948) discussed the distribution of *Eucalyptus* species between the Torrens Gorge and Port Noarlunga. In this area, nine species were found in extensive and complex patterns of distribution which enabled the authors to prescribe on the basis of soil nutrients and climate, geo-

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graphical limits for each species. As *Eucalyptus elaeophora* F. Muell. appeared in only the most northerly portion of the area mapped, and was known to be common farther north, a more comprehensive study of this species was deferred. This paper presents the results of this later investigation.

Adamson and Osborn (1924) gave an excellent introductory account of the distribution of *E. elaeophora*. They indicated (1) that the southern boundary of the species was just south of the Torrens Gorge; (2) that the forests occurred on rugged hills with shallow, stony soils formed from metamorphosed Archaean (then considered to be Pre-Cambrian) rocks, notably hard schists, crystalline quartzites and gneisses; and (3) that less water was available in forests of *E. elaeophora* than in the *E. obliqua* forests to the south. Winter mists, common in the Ranges to the south of the *E. elaeophora* zone, would induce wetter conditions favouring *E. obliqua* even in areas of similar rainfall, viz. 30 to 35 inches per annum where *E. elaeophora* was found.

Wood (1930) reiterated the above conclusions and later (1937) in his book, "The Vegetation of South Australia", added a little further information on its distribution – "from about Mount Crawford southwards to the Torrens Gorge", the general distribution of the Archaeozoic rocks – and noted that the soil formed from these rocks is shallow, somewhat podsolized and that, in some areas, lateritic residuals may be found.

Specht and Perry (1948), as mentioned above, noted the presence of *E. elaeophora* south of the Torrens Gorge, and indicated that it was found in podsolic soils developed over the "Stonyfell quartzite" on Black Hill and on soils, erroneously termed ferrimorphic soils, developed over Archaean schists and gneisses.

In a recent soil survey, Jackson (1957) made some general remarks on the vegetation. He noted that both *E. obliqua* and *E. elaeophora* were the most common trees in the sclerophyll forests he examined (see area C, Fig. 1). The two species were co-dominant in scrubs north of Millbrook Reservoir, on the Mount Gawler, Millbrook, Kersbrook, Mount Gould and Horse Gully soil associations. To the east of the longitude of Birdwood, on the Birdwood soil association, *E. elaeophora* was co-dominant with *E. fasciculosa* while *E. obliqua* was sole dominant in sclerophyll forests on the Lobethal and Kangaroo Creek soil associations on the south boundary of the Hundred of Talunga.

This new evidence of Jackson together with the detailed maps presented in this paper enables a much broader picture of the distribution of *E. elaeophora* in the Mount Lofty Ranges to emerge than Adamson and Osborn could possibly have seen in their reconnaissance survey almost forty years ago.

The main area selected for study extended from the Torrens Gorge in the south to Mount Gawler in the north, from Golden Grove in the west to Mount Gould in the east (see area A, Fig. 1). This was chosen, because it was a logical extension of Specht and Perry's original survey, and also because it showed an excellent sequence of rocks of Archaeozoic and Pre-Cambrian age (Torrensian series) varying greatly in mineral composition (Sprigg *et al.*, 1951). As well, deep Eocene sands are found on the western boundary of the area below the Eden scarp in the Anstey Hill region.

A smaller area, the Barossa Goldfields, mapped by one of us (P.N.H.) was chosen because it illustrates the most northerly limits of *E. elaeophora* in the Mount Lofty Ranges, an area where the rocks mentioned above are largely masked by Tertiary laterites and deep sands (Campana and Whittle, 1953).

A mapping procedure similar to that used by Specht and Perry (1948) was used in this survey; namely, the distribution of the Eucalyptus species on every ridge and valley was projected onto contour maps (Military Ordnance maps)

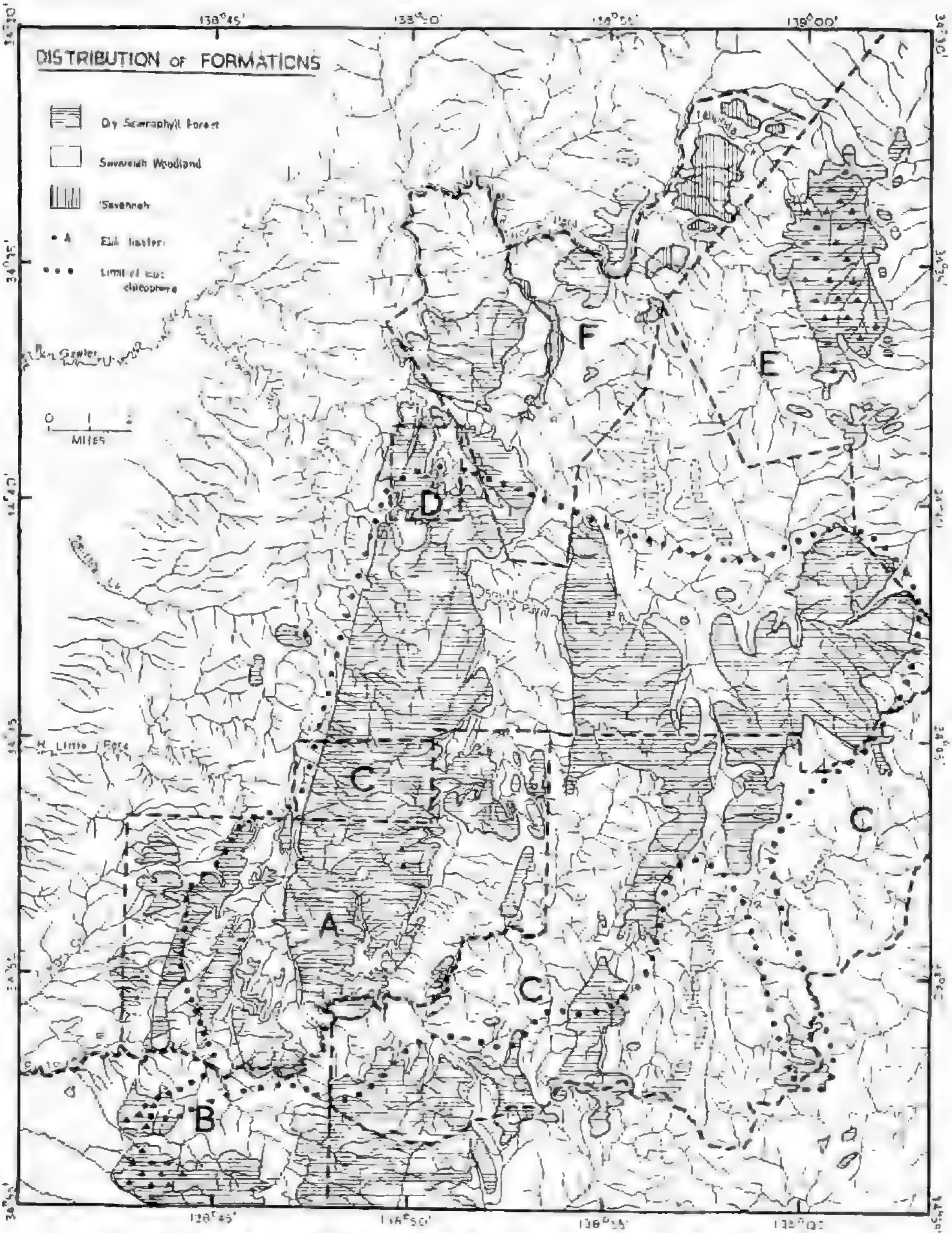

Fig. 1. Map showing the distribution of plant formations, savannah woodland, dry sclerophyll forest and savannah, between the Torrens Gorge and the Barossa Valley. The distribution of both *E. elaeophora* and *E. baxteri* within the dry sclerophyll forest is indicated. Detailed vegetation maps of Areas A and D are included in this paper (see Figs. 3 and 4). Area B is discussed by Specht and Perry (1948). Soil surveys of Jackson (1957) and Northcote and deMooy (1957) and Northcote (1959) cover the areas indicated by Areas C, E and F respectively.

TABLE 1.

Distribution of dry sclerophyll forest and savannah woodland formations in relation to geology and soils.

	Dry Sclerophyll Forest Formation			Savannah Woodland Formation		
	Parent Material	Soil Mapping Unit	Reference	Parent Material	Soil Mapping Unit	Reference
Recent to Tertiary	*Alluvial Deposits*	Nuriootpa family RS2 (unnamed soil group)	Northcote (1959)	*Alluvial Deposits*	Para family	Northcote (1959)
		Moppa-Vine Vale family	Northcote (1959)		Kroemer family	Northcote (1959)
		Nuriootpa family RS3 (unnamed soil group)	Northcote (1959)		Bilyara series 4	Northcote (1959)
					Bethany, Kabininge families	Northcote (1959)
					Torrens, Gumeracha Associations	Jackson (1957)
	Eocene lacustrine sands	Birdwood B. Association	Jackson (1957)	*Lacustrine sediments*	Kabininge family	Northcote (1959)
		Deep silicous sands of strongly acid reaction*	Specht & Perry (1948)	*Eocene marls*	Paradise Association	Aitchison & Sprigg (1954)
		Blewitt Springs Sand	Rix & Hutton (1953)			
	Tertiary laterites	Birdwood C. Association	Jackson (1957)			
		Residual lateritic podsols**	Specht & Perry (1948)			
		Incrassata family, Unnamed soil series 1	Northcote (1959)			
		Unnamed soil group SC1	Northcote (1959)			
		Barossa	Northcote (1959)			
Early Palaeozoic	*Mt. Kitchener and Tanunda Creek Granites*	Ridge Vale — Potts Spring — Yamba Soil combination	Northcote and De Mooy (1957)	*Kanmantoo schists*	Mount Pleasant, McVittie Hill Associations	Jackson (1957)

Precambrian	*Aldgate sandstone*	Horse Gully Association. Podsols and skeletal quartzites.	Jackson (1957) Specht & Perry (1948)	*Castambul, Montacute and Beaumont dolomites*	Terra Rossa	Specht & Perry (1948)
	Stonyfell quartzite	Mt. Gould Association Podsols and skeletal quartzites Birdwood A Association The Peak Soil Combination	Jackson (1957) Specht & Perry (1948) Jackson (1957) Northcote (1957)	*Upper and Lower Phyllites* (Rainfall <35 in. p.a.)	Forreston and Cudlee Creek Assns. Trial Hill Soil Combination Grey brown podsols (with high nutrient status)	Jackson (1957) Northcote (1957) Specht & Perry (1948)
	Upper and Lower phyllites (rainfall >35 in. p.a.)	Lobethal, Kangaroo Creek. Grey brown podsols (with low nutrient status)	Jackson (1957) Specht & Perry (1948)	*Glen Osmond Slates*	Grey brown podsols (with high nutrient status)	Specht & Perry (1948)
Proterozoic	*Torrensian series. Jointed quartzites and associates*	Unnamed soil group Sk1 Unnamed soil series YP1	Northcote (1959) Northcote (1959)	*Torrensian series. Phyllitic slates and associates*	Wilsford family	Northcote (1959)
Archaean	*Schists and gneisses*	Mt. Gawler, Millbrook Associations Ferrimorphic soil†	Jackson (1957) Specht & Perry (1948)	*Granulites (formerly "Houghton diorite")*	Inglewood Association	Jackson (1957)

* These were subsequently examined in the Blewitt Springs area by Rix and Hutton (1953). They are allied to the Golden Grove-Tea Tree Gully sands. Sandy soils in the Barossa Goldfields are solodised solonetz soils similar to those described by Northcote *et al.* (1954)

** Jackson (1957) combines three distinct soil associations in his Birdwood Association.

† Now known to be an error.

after a detailed ground survey. As the density of the species has been greatly altered by fire, woodcutting and clearing, no attempt was made to indicate the relative dominance of the various species; only the presence of a species in any area was delineated.

A reconnaissance soil survey of the areas studied was made, but as Jackson's soil survey (1957) overlaps half of our area, it is redundant to publish our map. Divergent interpretations and notes on the area outside his survey will be noted in the text.

DISTRIBUTION OF PLANT FORMATIONS

In order to see the distribution of *E. elaeophora* in the Mount Lofty Ranges in perspective the distribution of the two major plant formations, dry sclerophyll forest and savannah woodland, was mapped throughout the area concerned by means of aerial photographs and ground reconnaissance.

In Fig. 1 the limits of the dry sclerophyll forests are shown from the Barossa Valley (Tanunda) in the north to Lobethal in the south, from the edge of the Ranges in the west to Mount Pleasant in the east. The formation does not appear to extend into areas of the Mount Lofty Ranges to the east of longitude 139°03′ E.

Adamson and Osborn (1924) noted trees 60 to 70 feet in height, but usually the eucalypts were somewhat smaller. In the drier limit (20 to 25 inches per annum) the eucalypts, usually *E. fasciculosa*, are stunted, twisted and scattered; the formation is a tall sclerophyll shrub woodland (Wood and Williams, 1960). This is particularly so on the deep Tertiary sands between Golden Grove, Tea Tree Gully and Highbury (Sprigg *et al.*, 1951), and again on the sands extending from the Barossa Goldfields through Sandy Creek and along the eastern edge of the Barossa Valley (Campana and Whittle, 1953). Here the soils show characteristics, such as an increase in sodium in the clay complex, typical of solods and solodized solonetz soils (Northcote *et al.*, 1954). Associated with these soils, it is not surprising to find certain mallee species (*E. incrassata* - Section 46, Hundred of Moorooroo; *E. gracilis* – Barossa Goldfields) appearing together with *Melaleuca uncinata* and *Baeckea behrii* amongst the usual assemblage of undershrubs. These stands approach a sclerophyll mallee subformation (Wood and Williams, 1960). This subformation formerly extended some distance to the north of Fig. 1, but is now largely cleared for vineyards.

In general, the dry sclerophyll forest formation or any of its variants is restricted in its distribution. The savannah woodland formation is much more widespread. In addition to the two major plant formations, dry sclerophyll forest and savannah woodland, there are small areas of savannah associated with the following soils; Wiesenboden-Lyndoch, grey and brown soils of heavy texture – Tanunda and grey and brown soils of heavy texture - Altona (see Table 1, Northcote, 1959). These are indicated in Fig. 1.

TOPOGRAPHY AND GEOLOGY

Aspects of the physiography and geology of the area over which *Eucalyptus elaeophora* is distributed (Fig. 1) have been examined by many geologists over the last eighty years. Earlier work by Scoular (1879, 1880, 1882), Brown and Woodwood (1885), Howchin (1906, 1915, 1926), Benson (1909), Hossfeld (1925, 1935), England (1935), and Alderman (1938, 1942) provided a sound basis for the more recent and comprehensive studies of Sprigg (1945, 1946), Spry (1951), Sprigg *et al.* (1951) and Campana and Whittle (1953, 1955). Most of the geological strata of the area are of Archaean or Pre-Cambrian (Torren-

sian Series) age. The Archaean rocks, various schists and gneisses, form the core of the ranges and are often masked by deep beds of Pre-Cambrian sandstones, grits, quartzites, limestone and phyllites. In some areas, especially east of the Williamstown-Lyndoch fault line, regional metamorphism has altered these rocks to epidote quartzites, saccharoidal quartzites, marbles, sericite schists, knotted schists, etc.

During the early Palaeozoic these beds were extensively folded, viz. Humbug Scrub and Lookout Tower (Warren Reservoir) anticlines; Gould Creek, Williamstown (along Williamstown-Lyndoch road) and Mount Crawford-Barossa Range synclines. Subsequently they were extensively peneplained until little relief was apparent other than the monadnock structures of Mounts Lofty, Barker, Torrens, Gawler, Crawford, Pewsey Vale Peak and Kitchener. Meandering streams such as the Onkaparinga, Torrens, North Para and South Para rivers drained the landscape.

Early in the Tertiary (Eocene) considerable depths of sands, clay and ferruginous gravel were deposited in the beds of lakes and streams on the low-lying countryside. These non-marine sediments, as well as the older rocks, were subsequently subjected to widespread lateritisation which formed ironstone crusts resistant to erosion.

Tertiary (Miocene-Pleistocene) tectonic movements rejuvenated the relief by a general uplift of the hills of the area. Differential block-faulting, related to the Early Palaeozoic folding, has produced the present orography. In the area under discussion, the scarps produced by the Para, Eden and Kitchener Faults dominate the landscape. Considerable erosion by the antecedent streams (Onkaparinga, Torrens and Para Rivers) and many later ones have dissected the fault blocks so formed into the present topography. The rate of dissection is influenced by the nature of the rock; rocks such as quartzites, sandstones and grits resist erosion to produce rugged topography which contrasts with the rounded ridges with gentle slopes produced from more easily weathered rocks.

The lateritic duricrust has also resisted erosion on the plateau surface of some fault-blocks, e.g. around Paracombe, Humbug Scrub and even in small areas on the slopes of the former monadnock, Mount Gawler, but, in general, the laterite has been completely dissected. A general picture of the topography can be gained from Fig. 2 on which contours for the 500 feet levels are indicated. The former monadnock, Mount Kitchener (1,965 feet), Mount Pewsey Vale Peak (2,064 feet), Mount Crawford (1,844 feet), Mount Gawler (1,779 feet), Mount Lofty (2,384 feet) and Mount Torrens (1,913 feet) dominate the landscape.

Considerable areas of the Eocene lacustrine deposits are now seen from the Barossa Valley south-westwards into the Barossa Goldfields district. South of this district they are found in small, dissected areas formerly continuous with the Golden Grove-Paradise area where considerable deposits are still obvious. At Paradise they disappear beneath the Upper Eocene marine strata. A similar area may be seen in the old lake basin east of Mount Crawford.

Elsewhere the underlying Pre-Cambrian and Archaean rocks have been exposed. The Archaean is prominent in the anticline running from the Torrens Gorge south of Mount Gawler through the Humbug Scrub area as far north as the Barossa Goldfields. Areas of Archaean rock near Inglewood and Kersbrook are apparently "granulites derived from lime-magnesia rich sediments by high-grade regional metamorphism combined with potash and soda metasomatism" (Spry, 1951). These areas were formerly called "Houghton diorite" by Benson (1909).

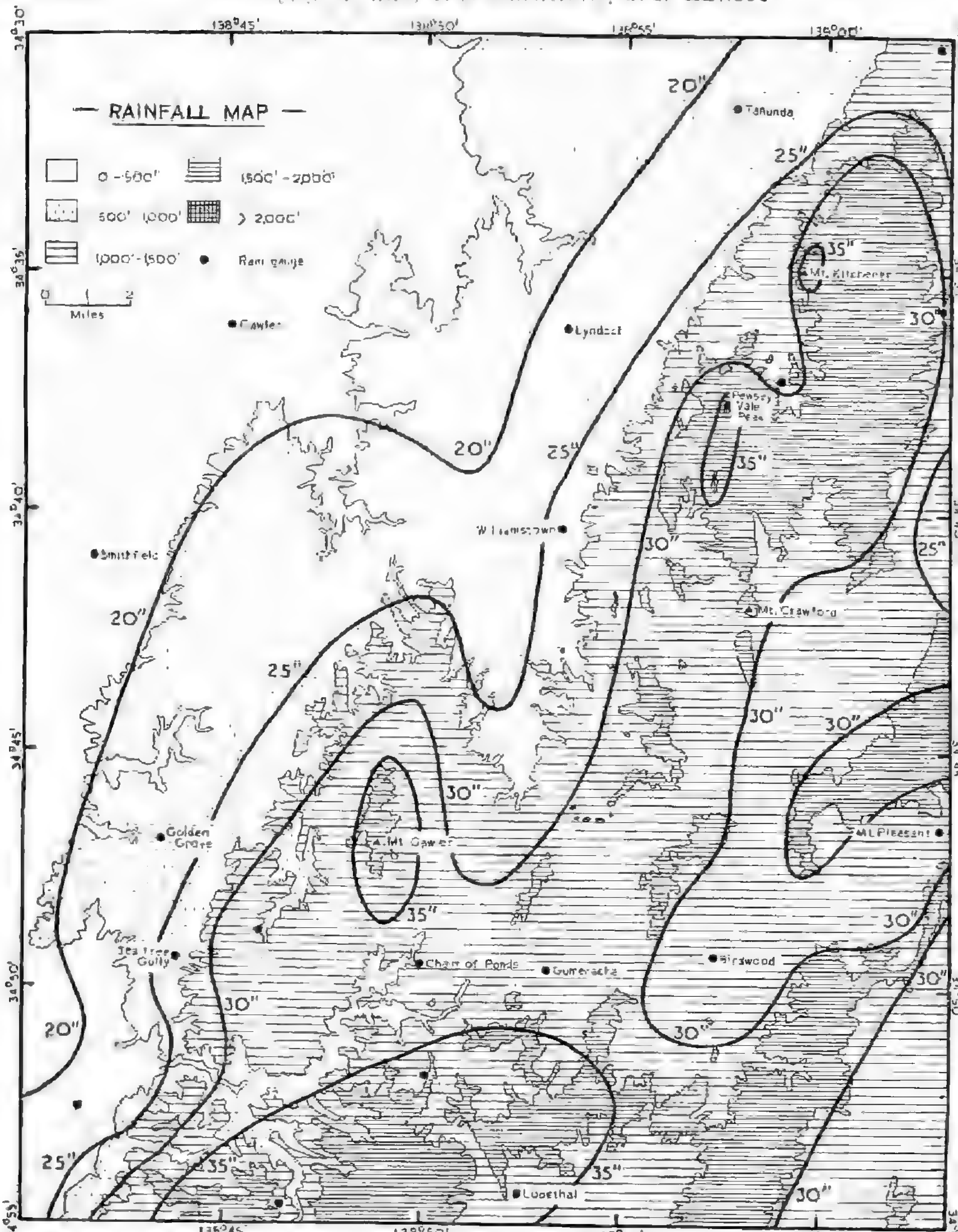

Fig. 2. Rainfall-altitude map of the area shown in Fig. 1.

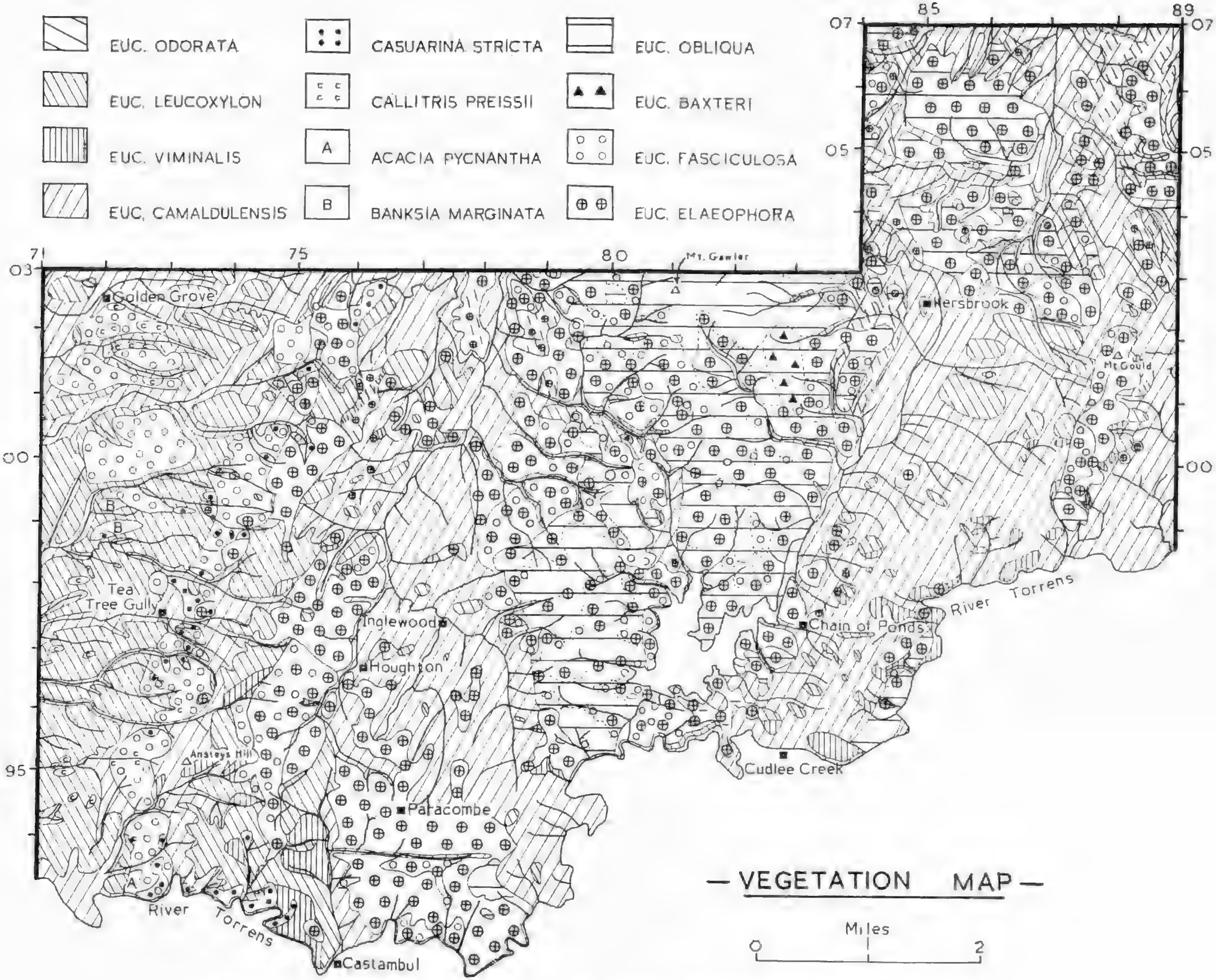

Fig. 3. Detailed vegetation map of area A shown in Fig. 1. Grid references on the Adelaide military ordnance map are indicated

The basal beds of the Pre-Cambrian rocks (Aldgate sandstone) outcrop both on the east and the west of these Archaean rocks. The same basal rocks, though highly metamorphosed, also outcrop along the anticlinal ridge just west of the Warren Reservoir (the Lookout Tower Anticline).

Considerable depths of slates and phyllites interspersed with many bands of quartzite and some shallow beds of limestone or dolomite are prominent in the younger Pre-Cambrian outcrops. Ecologically the narrow outcrops of the Castambul, Montacute and Beaumont dolomites are of little significance. However, the many quartzitic beds, especially the thick Stonyfell quartzite, play a large part in the distribution of the vegetation. North of the Torrens Gorge and west of the Archaean rocks, quartzite outcrops along the Eden scarp in quite considerable areas; north of the latitude of Golden Grove, however, the outcrops are reduced to narrow bands usually too thin to be of much ecological significance. To the east of the Archaean core, three major quartzitic outcrops are found running roughly north and south – one ridge through the Mount Gould area and two ridges from Mount Crawford forest southward. One of the latter runs towards Lobethal and the other towards Mount Torrens. Similar ridges, though much metamorphosed, may be seen to the north of the Mount Crawford Forest where they form the backbones of the Mount Crawford-Barossa Range area.

Palaeozoic schists and schistose quartzites of the Kanmantoo Series are prominent on the eastern edge of the area. Granitic rocks have intruded through them in the Mount Kitchener and Tanunda Creek area.

From the broad ecological viewpoint, there are two major geological groups. One group of rocks supports a dry sclerophyll forest and/or woodland formation, viz.:

Caenozoic	Tertiary laterites.
	Eocene lacustrine sands.
Early Palaeozoic ..	Mount Kitchener and Tanunda Creek granites.
Pre-Cambrian .	Aldgate sandstone.
(Torrensian Series) .	Stonyfell quartzites.
	Other quartzitic beds if not greatly intermixed with slates or phyllites.
Archaean	Schists, gneisses and augen-gneisses.

The other group of rocks supports a savannah woodland formation, viz.:

Caenozoic .. .	Recent alluvial floodplains.
	Eocene marls (near Paradise).
Early Palaeozoic ...	Kanmantoo schists and schistose quartzites.
Pre-Cambrian	Castambul, Montacute and Beaumont dolomites.
(Torrensian Series) .	Lower and Upper phyllites with their minor quartzitic bands.
	Glen Osmond slates.
Archaean	Granulites (formerly called "Houghton diorite").

SOILS

The diverse geological formations mentioned above have had a marked influence on the soils to be found in the area. Since Specht and Perry published their ecological survey in 1948, a number of soil surveys has been made in the Mount Lofty Ranges, viz. Rix and Hutton (1953), Aitchison and Sprigg (1954), Northcote *et al.* (1954), Clarke (1957), Jackson (1957), Northcote and de Mooy (1957), and Northcote (1959). Table 1 summarises the soil-geological relation-

TABLE 2.

Chemical analyses of soil samples from dry sclerophyll forest and savannah woodland formations in the Mount Lofty Ranges.

Chemical Property	Soil Depth (inches)	No. of samples	*Savannah Woodland Formation.* Mean and Standard Error of mean	No. of samples	*Dry Sclerophyll Formation* Mean and Standard Error of mean	**Difference Significant at
pH	0-12	50	6·47 ± ·112	26	5·70 ± ·067	P < ·01
Nitrogen (% N.)	0-12	29	0·127 ± ·0123	18	0·074 ± ·0104	P < ·01
Phosphorus (% P.)	0-12	24	0·026 ± ·0041	19	0·007 ± ·00092	P < ·01
Potassium (% K.)	0- 3	21	0·29 ± ·043	8	0·15 ± ·068	N.S.†
Total Soluble salts %	0-12	40	0·022 ± ·0038	17	0·016 ± ·0027	N.S.†
Chloride as NaCl %	0-12	40	0·008 ± ·0021	17	0·006 ± ·0017	N.S.†
Exchangeable cations						
i) Exchangeable Ca*	0- 3	37	7·42 ± ·118	12	3·08 ± ·318	P < ·01
ii) Exchangeable Mg*	0- 3	37	1·89 ± ·171	12	1·38 ± ·231	N.S.†
iii) Exchangeable K*	0- 3	37	0·68 ± ·089	12	0·28 ± ·038	P < ·01
iv) Exchangeable Na*	0- 3	37	0·25 ± ·054	12	0·15 ± ·026	N.S.†

* M-equiv./100 g. soil.

** Analyses were carried out by t-test where variances were equal; where they were unequal, the Sukhatme test was used.

† N.S.—not significant at P = 0·05

ships found by these authors and compares them with the broad classification used by Specht and Perry. It is obvious that the two plant formations of the area are found on a wide variety of soil associations. In 1948, Specht and Perry analysed some 23 soil profiles, usually only subdivided into A and B horizons, for texture, hydrogen ion concentrations, phosphorus and nitrogen. These preliminary analyses indicated that nutrient status of the soil controlled the distribution of the two plant formations found in the area. The dry sclerophyll forest was found on those soils of low nutrient status (as indicated by phosphorus and nitrogen levels); the savannah woodland on soils with higher fertility.

Detailed soil surveys of subsequent workers have been accompanied by comprehensive mechanical and chemical analyses of typical profiles by the Soil Chemistry Section of the Soils Division of C.S.I.R.O. It is possible now to contrast the fertility of soils of these two formations with much greater precision. As most of Specht and Perry's analyses were made on the surface twelve inches of soil, comparable values were calculated from the more recent data. The levels thus calculated though lower than those of shallower layers of soil, showed the same order of difference as that observed in the surface two or three inches. Some analyses (namely, exchangeable cations, percentage potassium) had been made on only the surface two or three inches of soil. The data, thus computed, are presented in Table 2.

Values for hydrogen ion concentration, nitrogen, phosphorus, exchangeable calcium and potassium for soils of the savannah woodland formation are significantly higher than those of the dry sclerophyll forests. Other analyses (total potassium, total soluble salts, chlorides, exchangeable magnesium and sodium), although they appear lower in soils of the dry sclerophyll forest formation, are not significantly different. In effect, the hypothesis of Specht and Perry (1948) that the savannah woodland is found on soils of higher fertility than that of the dry sclerophyll forest is confirmed.

CLIMATE

Recently Coote and Cornish (1958) made a detailed statistical analysis of the rainfall of the Mount Lofty Ranges. A close correlation between rainfall, altitude, latitude and longitude was shown. From this they were able to construct maps of the mean monthly rainfall of the Ranges.

Unfortunately they did not compute mean annual isohyets. Using their monthly regression equations (see Martin, 1960), mean annual rainfall was calculated for every 5-second latitude and longitude intersection of the area. These figures, plus the infrequent rain-gauge records, were used to construct the annual rainfall-topography map of Fig. 2. The high peaks of Mt. Kitchener, Mt. Pewsey Vale, Mt. Gawler and the country to the south of Millbrook Reservoir induce the highest rainfall (35 to 40 inches per annum) of the area. Much lower annual rainfall (less than 20 inches per annum) occurs on the lowlands to the west and north as well as in the rain shadow towards the east.

As indicated in the first paper in this series (Specht and Perry, 1948), this rainfall has a well-marked winter maximum, coinciding with low temperatures (mean July temperature is 45° F.), alternating with a summer minimum when temperatures are high (mean January temperature is 65° F.). This is a typical Mediterranean climate.

Distribution of the two plant formations, dry sclerophyll forest and savannah woodland, is little influenced by climate in this area (compare Figs. 1 and 2). The Castambul-Lobethal area may be an exception where the higher rainfall (greater than 35 inches per annum) may have markedly influenced the fertility

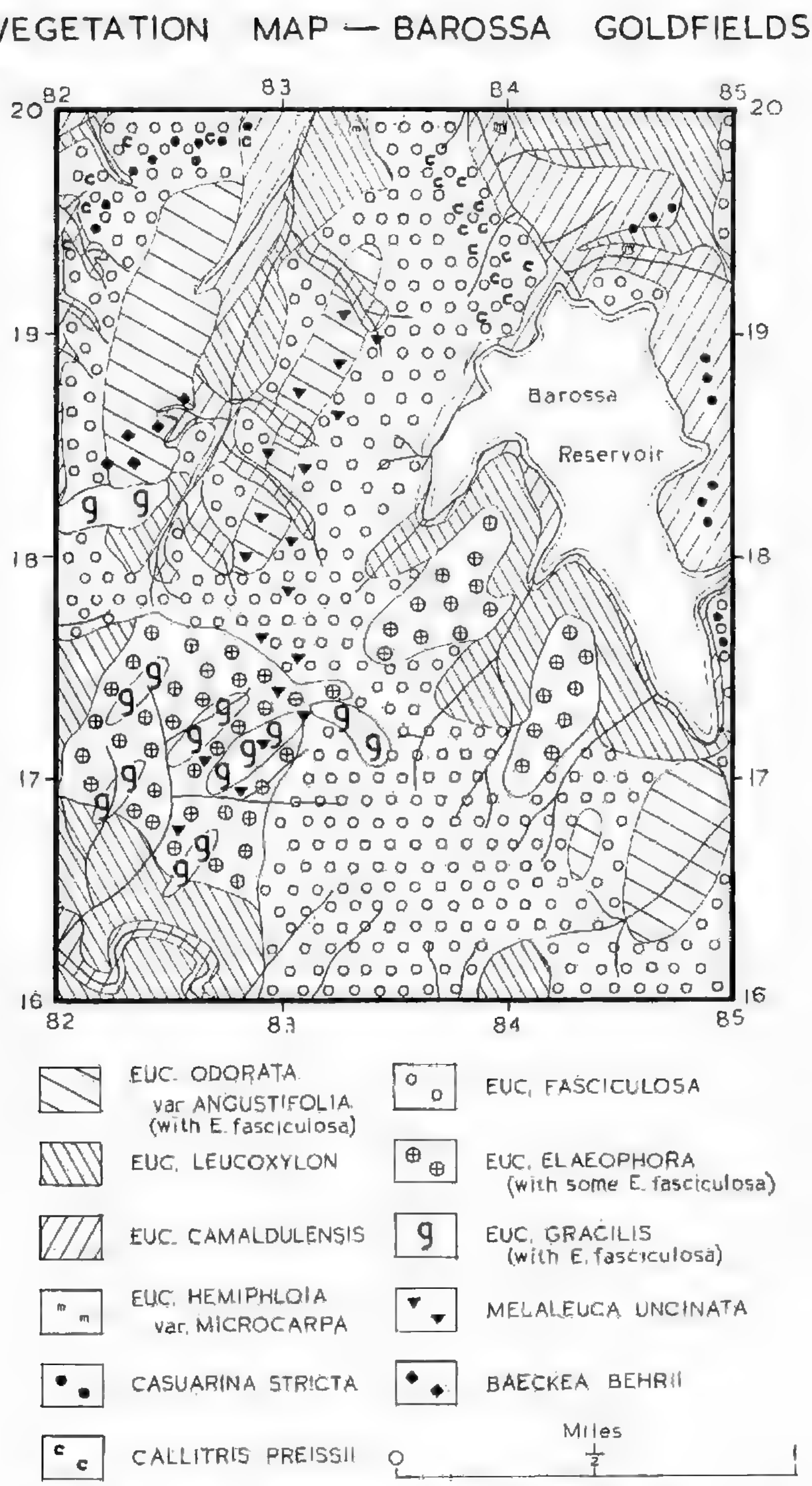

Fig. 4. Detailed vegetation map of Barossa Goldfields, Area D of Fig. 1. Grid references on the Cawler military ordnance map are indicated.

of soils such as Lobethal and Kangaroo Creek associations in favour of the dry sclerophyll forest (see Specht and Perry, 1948, p. 103).

However, distribution of individual species within each plant formation is markedly influenced by climate, especially microclimate, as will be shown below.

DISTRIBUTION OF *EUCALYPTUS ELAEOPHORA*

(1) *In the Mount Lofty Ranges*

The distribution of *Eucalyptus elaeophora* in the Mt. Lofty Ranges is indicated in Fig. 1. The species does extend a short distance outside this boundary, but always as an insignificant part of the community and then often represented by trees which suggest that they are hybrids of *E. elaeophora* and *E. viminalis* (probably not even pure *E. viminalis* but hybrids between it and *E. aromaphloia* (Pryor, 1955b) – formerly considered as *E. viminalis* var. *huberiana* by Burbidge, 1947). Such limited areas of these hybrid forms may be seen on the Tertiary laterites just west of Tungkillo (lat. 34°52′S., long. 139°00′E.), on the narrow quartzite outcrop running north from Mt. Torrens to the River Torrens, and on the narrow, metamorphosed quartzite ridges just north of Mount Crawford. This information is contrary to that of Jackson (1957, p. 13), who stated that *E. elaeophora* was co-dominant with *E. fasciculosa* to the east of the longitude of Birdwood. *E. elaeophora* is really quite rare in this area.

In all areas, *E. elaeophora* is found only in the dry sclerophyll forest formation. Within that formation, it appears to be much more widespread than originally thought (Adamson and Osborn, 1924; Wood, 1937), being found on Tertiary laterites, Aldgate sandstone, Stonyfell quartzites as well as the Archaean schists and gneisses. Small pockets of the species also extend onto the phyllites of low nutrient status (presumably leached by the rainfall greater than 35 inches per annum), though these pockets are rare. In fact, the species may be found on all rocks supporting a dry sclerophyll forest mentioned in Table 2, except the deep Eocene lacustrine sands and the Mount Kitchener-Tanunda Creek granites. The deep sands are found on the drier limit of the species thus precluding its establishment. The Tanunda Creek Granites appear to be the most infertile soils of the area, possibly too infertile to support *E. elaeophora*, only gnarled *E. baxteri* and *Xanthorrhoea semiplana* growing there.

It is clear from Fig. 3 that the distribution of *E. elaeophora* overlaps that of *E. obliqua*, *E. fasciculosa*, and even the small area of *E. baxteri* on the western slopes of Mount Gawler. Because of this overlap, the mean soil data shown in Table 2 for the dry sclerophyll forest, were almost identical with those for the component eucalypt species.*

The rainfall limits of *E. elaeophora* are well defined on the map. On the drier limit, the species is first found in isolated pockets amongst *E. fasciculosa* on the skeletal quartzites on top of the Eden scarp (Anstey's Hill-Golden Grove). The species seems to occur in the wetter habitats of gullies and southerly slopes. This area lies approximately along the 27-28 inch annual isohyet. Not far to the east of the escarpment the soil profile becomes well developed on quartzites allied to those on the scarp. Here *E. elaeophora* is widespread, sometimes co-dominant with *E. fasciculosa*, sometimes in almost pure stands.

Farther east, *E. elaeophora* extends into the wetter areas of the Archaeozoic rocks (with or without lateritic remnants). In the Paracombe area it again

* The limited soil data for *E. baxteri* were the only exceptions; percentage nitrogen (0·017), percentage phosphorus (0·004), exchangeable calcium (2·1 milli-equivalents p.c.) and exchangeable magnesium (0·5 milli-equivalents p.c.) were half to two-thirds that of the mean for the formation. *E. elaeophora* was absent from all these soils.

forms almost pure stands, mixed occasionally with trees of *E. fasciculosa*. However, in the wettest part of the area around the massif of Mount Gawler, the species is greatly admixed with *E. fasciculosa* and especially with *E. obliqua*. On these Archaeozoic rocks, *E. fasciculosa* is mainly found with *E. elaeophora* on shallow soils usually with a northerly aspect. On deeper soils *E. obliqua* is found co-dominant with *E. elaeophora* and forms almost pure stands in the wettest sites on the east side of Mount Gawler and on the ridge to the west of Millbrook Reservoir. It is apparent then that the upper rainfall limit of *E. elaeophora* in the area is 35 to 36 inches per annum.

The lower rainfall limit of 27-28 inches per annum shown on Fig. 3 may be a little high. The species is present in small areas of deep infertile soil on the

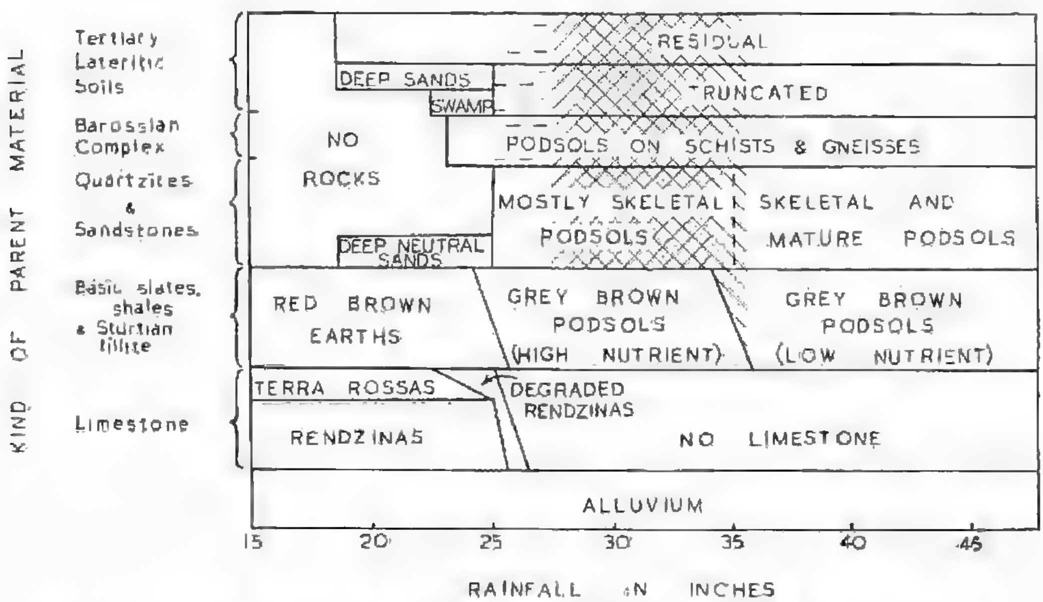

Fig. 5. Diagram illustrating the distribution of *Eucalyptus elaeophora* in relation to soils and rainfall. The figure is altered slightly from that given by Specht and Perry (1948); the schists and gneisses of the Barossian Complex are found in rainfall areas as low as 23 inches per annum. Hatching from right to left (downwards) indicates presence on south-facing aspects only. Cross hatching indicates presence on both aspects. Broken horizontal lines indicate presence only on soils of high water-retaining capacity.

Barossa Goldfields (Fig. 4), where, although meteorological records are scanty, the rainfall may be as low as 23 inches per annum. Here, however, the soil probably has better water-relationships than those found in areas of similar rainfall on Fig. 3, as it is a deep soil with a clay-loam A horizon.

It appears then that *E. elaeophora* can grow on a wide range of infertile soils which characteristically support a dry sclerophyll forest. Exceedingly low fertility may exclude the species for it is not found on deep sands or on soils developed from Tanunda Creek granites where *E. baxteri* or *E. fasciculosa* survive. In general, the species extends from approximately 27 to 36 inches of rainfall per annum, although it may be found in drier areas (as low as 23 inches per annum) in moist pockets. This distribution is summarized in Fig. 5.

These climatic and edaphic limits give some clues which may explain why *E. elaeophora* is not found farther to the south. Much of the Ranges

TABLE 3.

Environmental factors controlling the distribution of *Eucalyptus elaeophora* in various parts of Australia.

State	Locality	Topography	Rainfall Limits	Soil	Reference	Mean monthly temperature (July and January)
S. Aust.	Hills surrounding Wilpena Pound (3 peaks on northern side including St. Mary's Peak)	Highlands: From 2,500 feet to the summits.	Approx. 26 inches p.a.	In rock clefts (Pound quartzites).	Brooker (personal communication.)	50-78°F*
	Elders Range (Flinders Range)	Highlands: towards the summit.	Approx. 26 inches p.a.	In rock clefts (Pound quartzites).	Boomsma (1960)	50-78°F*
	Southern Flinders Ranges	Highlands (1,500 ft to the summits)	Greater than 26 inches p.a.	Skeletal soil, podsols from quartzite.	Boomsma (1946)	48-73°F**
	Western Clare Hills	Highlands (1,500 feet)	27-30 inches p.a.	Skeletal soil, podsols (sandy loam over clay subsoil).	Boomsma (1949)	47-70°F†
	Mount Lofty Ranges	Highlands (800-1,800 ft.)	27-36 inches p.a. (may be lower on favourable soils).	Podsolic soils, laterites, etc.	Specht *et al.* this paper.	45-65°F††
Vic.	Dandenong Ranges	Ridges and steep slopes of Lilydale and Beaconsfield Hills. North and west aspects of Dandenong Range (300-1,700 feet).	30**-48 inches p.a.	Skeletal soil, podsols (silty loam and sandy loam), krasnozem.	Clifford (1953)	45-65°F
	S. Riverina	Highlands — south and east slopes (1,500-2,000 feet).	25-27 inches p.a.	Shallow soil with little profile development.	Moore (1953)	45-70°F
	Monaro Region	Highlands (1,500 - 3,000 feet).	19-26 inches p.a.	Well drained podsols and lithosols	Pryor (1938) Costin (1954)	40-70°F
All States	General	500-2,000 (or 3,000 feet).	18-20 inches p.a.	Rocky sites, poor slate and granite soils.	Rodger (1953)	45-70°F

Recorded temperatures at * Angorichina ** Georgetown † Clare, will be higher than at actual sites of *E. elaeophora* in the highlands; those of Mt. Crawford†† are characteristic for the centre of the sand in the Mt. Lofty Ranges. ††This is the minimum rainfall of the area surveyed; *E. elaeophora* extends into drier habitats throughout Victoria.

to the south, centred around the Mount Lofty massif, have a rainfall greater than 35 inches per annum (Specht and Perry, 1948, p. 93). The only areas which support the dry sclerophyll forest formation to the west of the isohyet are (1) Black Hill, (2) Rocky Hill, Morialta, (3) Stonyfell Ridge, until the Eden-Moana Fault Block is reached at Belair (Specht and Perry, 1948, p. 115). *E. elaeophora* is found in small pockets on Black Hill, not on the drier side where the soil is predominantly steep, skeletal quartzite, and thus a drier habitat than is at first apparent, but on the mature podsolic soils developed on the eastern side of the hill. Such mature podsols are rare on the west side of

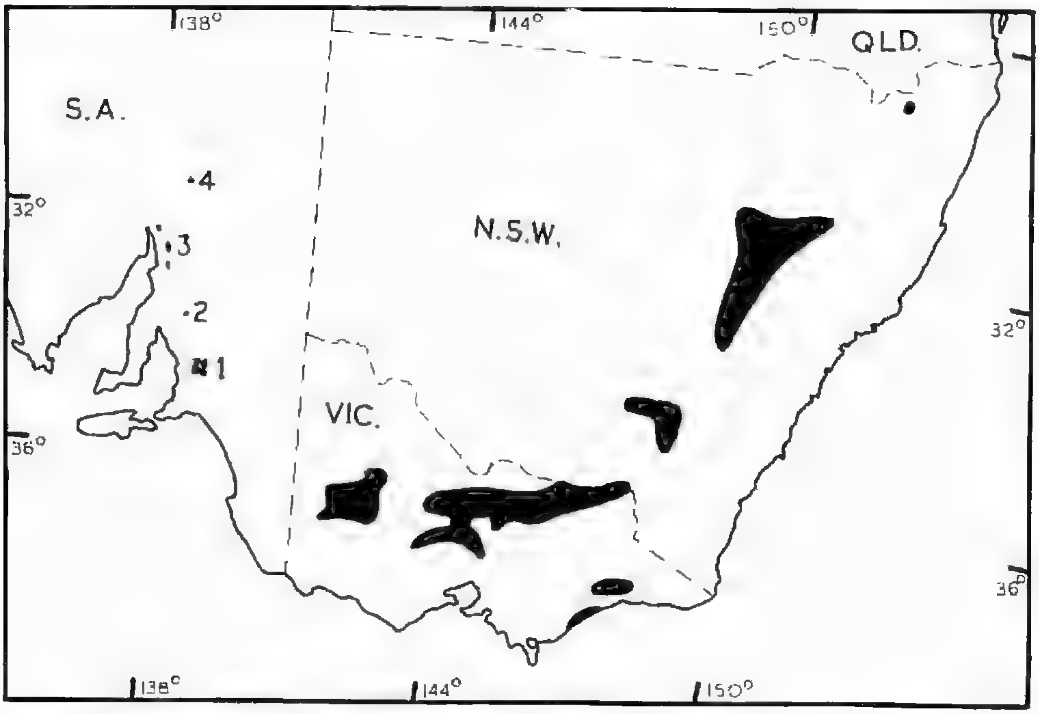

Fig. 6. Distribution of *Eucalyptus elaeophora* throughout Australia. The areas 1 to 4 in South Australia are discussed by Specht *et al.* (this paper), Boomsma (1949), Boomsma (1946), and Boomsma (1960), respectively. The distribution in the eastern States is mainly after Clifford (1953).

Rocky Hill and Stonyfell Ridge where the rainfall is less than 35 inches per annum. In addition to the effect of distance on the availability of seed, it is unlikely that these sites are suitable habitats for germination and establishment of *E. elaeophora*.

Suitable soils are even less common on the eastern sides of the Ranges in areas where the rainfall falls below 35 inches per annum (Fig. 2). Small ridges like Mount Charles and Mount Barker are found, but they are so isolated from *E. elaeophora* stands that the species has not yet established itself. To the north of its present distribution in the Mount Lofty Ranges, both the soils (solonized sands in the Barossa Valley and very infertile soils on Tanunda Creek granites) and the climate appear to be so unsuitable as to preclude further spread of the species.

It appears then that this relic species has effectively occupied most suitable sites within the area and is prevented from expanding both to the north and the south by unfavourable climate and soils.

(2) *In Other Localities in Australia*

Fig. 6 indicates the scattered distribution of *E. elaeophora* throughout Australia. It is found in disjunct areas extending in an arc from the highlands near Queensland, through New South Wales, Victoria to the Mount Lofty Ranges and then up into the Flinders Ranges. The species is thus one of the many examples which indicate that major climatic changes have occurred in Australia in the not-so-distant past (Crocker and Wood, 1947).

Some environmental factors which may control the distribution of the species in these disjunct areas are summarized in Table 3. In all areas noted in this table, *E. elaeophora* is found in either a dry sclerophyll forest formation or in closely allied communities. It is usually found on ridges, always on infertile podsolic or related soils, the depth of which depends largely on the rainfall, e.g. deeper soils on the drier sites; shallow, skeletal, or exposed soils on the wetter sites. In all cases, the soils are well-drained.

As Rodger (1953) indicated, *E. elaeophora* is found in a wide range of climates from Mediterranean type with winter rainfall (South Australia), through a climate where rainfall is uniform throughout the year (Victoria-southern New South Wales), to a climate where summer rainfall tends to predominate (northern New South Wales).

In many areas, the highest rainfall where *E. elaeophora* occurs is far below its upper limit, e.g. in Flinders Ranges, Clare Hills, and S.E. Riverina. However, in the Mount Lofty Ranges, and the Monaro Region, the upper rainfall limit is certainly reached. It can be seen in Table 3 that under conditions of winter rainfall the *E. elaeophora* generally occurs in areas receiving a higher mean annual rainfall than it does under conditions of uniform or summer rainfall incidence, e.g. the limits of mean annual rainfall for the distribution of *E. elaeophora* in the Mount Lofty Ranges (winter rainfall incidence) and in the Monaro Region (uniform rainfall incidence) are compared below:

	Mean Annual Rainfall (in.)		Ratio Mean Annual Rainfall
	Mount Lofty	Monaro Region	Monaro Region/Mt. Lofty
Lower Limit	27	19	0·73
Upper Limit	36	26	0·72

A possible exception to the above is the reported occurrence by Clifford (1953) of *E. elaeophora* in areas in the Dandenong Ranges, Victoria, with uniform rainfall incidence receiving up to 48 inches mean annual rainfall. However, *E. elaeophora* hybridises freely with *E. goniocalyx*, a species common in wetter areas, thus making it difficult to determine the limits of the two species (Clifford and Binet, 1954). The upper limit of the mean annual rainfall given by Clifford (1953) may be too high.

The mean annual rainfall probably gives a poor indication of the water available at any particular time of the year for the maintenance of stands of *E. elaeophora*. Eucalypts generally make most active foliage growth in the summer (Specht and Rayson, 1957; Burbidge, 1960) and losses of moisture due to transpiration are highest at this period (Martin, 1960). It would, therefore, be expected that the amounts of water available (as rain and stored soil moisture) would be more critical at this time of year than at any other for the maintenance of stands of *E. elaeophora*. Thus, the amounts of available water at each month in localities where *E. elaeophora* occurs under conditions of different

rainfall incidence have been calculated by the method used by Martin (1960) and are shown in Fig. 7.

It has been necessary to use the relationship established by Martin (1960) between amount of available water and the Index of Evapotranspiration in communities of *E. elaeophora* in the Mount Lofty Ranges throughout all calculations, as, due to lack of data, the relationship has not been determined in other areas. In all these calculations it has been assumed that up to four inches of water can be stored within the root zone without loss by drainage.

It can be seen in Fig. 7 that at Queanbeyan or at Tarcutta (uniform rainfall incidence) the amounts of available water during the summer months (viz. January, February and March) are about twice as great as at Mount Crawford or at Clare (winter rainfall incidence), even though the mean annual rainfall at the sites of *E. elaeophora* at Mount Crawford (28 inches) or at Clare (27-30 inches)* is greater than at Queanbeyan (22 inches) or at Tarcutta (26 inches).

In winter rainfall areas with a mean annual rainfall less than Mount Crawford, it is conceivable that the amount of available water during the summer months may fall too low to support growth of *E. elaeophora*. Summer rainfall, however, enables this species to grow in areas of even lower annual precipitation.

DISTRIBUTION OF OTHER EUCALYPTS

All the other eucalypts found north of the Torrens Gorge have distribution patterns almost identical with those indicated by Specht and Perry (1948) for the area to the south.

A. Species of the Savannah Woodland

1. *Eucalyptus odorata* is found in only the north-west corner of Fig. 3 (Section 2165, Hd. Yatala, with a few isolated trees also in Sections 2180 and 5575). However, in the drier habitats to the west of the area, it is the dominant tree in the savannah woodland formation.

It is common along the uncleared areas of the Para scarp (e.g. Sections 2102-5, 2108, 2110, 2114-6, 2144, 2152 and 2284, Hd. Yatala, as well as areas to the north), and in small pockets on the Para Fault Block (Sections 2148, 2167 and 1560, Hd. Yatala), which have escaped agricultural development. Much of this area lies within the 20 to 25-inch isohyets on reasonably fertile soils. In the areas under survey, the species rarely extends into sites with rainfall as high as 30 inches per annum, as was noted by Specht and Perry further to the south, e.g. into the Belair National Park. The small stands in Sections 2180 and 5575, as well as clumps of hybrids (*E. odorata* x *E. leucoxylon*, similar to those recorded by Pryor, 1955a, in the vicinity of Burnside) in Sections 5461 and 5476, Hd. Yatala, were the only trees observed in the higher rainfall zone (25-30 inches per annum). This was not surprising as most of the fertile soils of this zone were deep, alluvial soils probably with a high water-retaining capacity, quite unlike the shallow, almost skeletal, soils of National Park.

2. *Eucalyptus leucoxylon* is a common tree in the savannah woodland formation between the 25 to 30 inch isohyets (Figs. 3 and 4). Here the species

* The mean annual rainfall estimated by Boomsma (1949) for the actual sites of *E. elaeophora* in the Western Clare Hills, given above, is greater than that recorded at Clare, from where the mean monthly data were obtained for the calculation of the available water at each month. The difference between the means of annual rainfall at Clare and at the actual sites of *E. elaeophora* can be attributed to differences in their altitudes. This topographic effect would be much more significant in the winter months when most of the rain is received in this district, and the effect in summer months would be almost negligible. The amounts of available water at each month during the summer would, therefore, be expected to be approximately the same at Clare as at the actual sites of *E. elaeophora*.

forms pure stands over the rolling countryside of the Para Fault Block and again on the broad, fertile ridges of the Eden Fault Block. The deeper soils of these broad ridges, as mentioned above, have a high water-retaining capacity, thus excluding *E. odorata* in favour of *E. leucoxylon*. This is markedly in

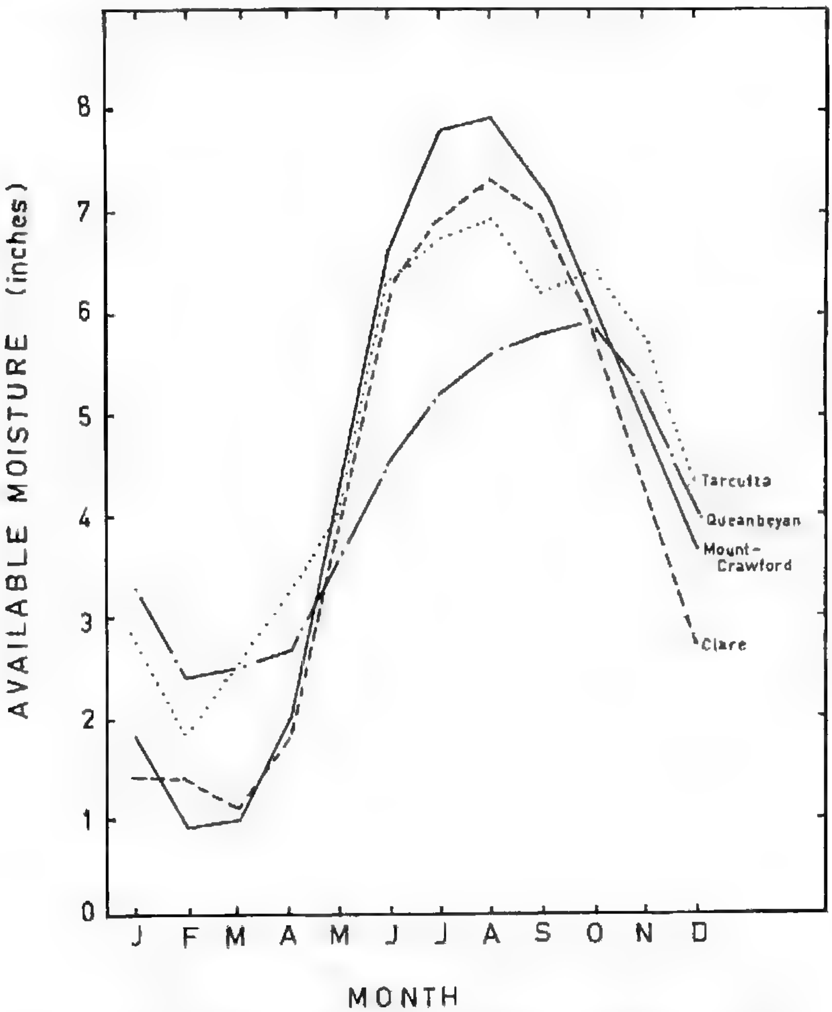

Fig. 7. The amounts of available moisture (rainfall plus stored moisture) in localities where *E. elaeophora* occurs. The amounts of available moisture for each month were calculated by the method used by Martin (1960). The relationship between the amount of available water and Index of Evapotranspiration in communities of *E. elaeophora* in the Mount Lofty Ranges established by Martin (1960) was used in all calculations, owing to lack of data from other areas. It was assumed that up to four inches of water could be stored within the root zone without loss by drainage.

contrast to the sharply dissected topography further south where shallow soils and aspect play a large part in the distribution of the two species in this climatic zone (Specht and Perry, 1948).

In areas with rainfall greater than 30 inches per annum, the species is restricted to exposed ridge tops, the rest of the savannah woodland is dominated by *E. camaldulensis*.

The species is also found in the more fertile valleys of the Archaeozoic complex, especially around Mount Gawler, where the vegetation is typically a dry sclerophyll forest formation. This distribution is identical with the stands of *E. leucoxylon* tonguing into the dry sclerophyll forest at Blewitt Springs to the south (Specht and Perry, 1948).

3. *Eucalyptus viminalis* is almost invariably found on southern aspects within the 30 to 36 inch isohyets, in habitats identical with those in which it is found south of the Torrens Gorge. Its distribution north of the Torrens Gorge is markedly restricted. *E. camaldulensis* appears to occupy all suitable habitats.

The hybrid, *E. viminalis* x *E. aromaphloia* (Pryor, 1955b), formerly referred to as *E. viminalis* var. *huberiana*, is found on the quartzitic ridges running north from Mount Torrens and again north of Mount Crawford. These hybrids are in communities allied to a dry sclerophyll forest and appear to replace *E. elaeophora*, rare trees of which may be found among the hybrids.

4. *Eucalyptus camaldulensis* confined to stream-beds below 27 inches per annum spreads out over both north and south aspects of most hills with rainfall between 27 to 35 inches per annum. As the headwaters of the Torrens and Para Rivers lie within this rainfall belt, much of the savannah woodland of the area is dominated by *E. camaldulensis*, with only small pockets of *E. leucoxylon* and *E. viminalis*.

The environmental range is identical with that indicated by Specht and Perry (1948).

5. *Eucalyptus hemiphloia* var. *microcarpa*. Three specimens of this tree were found to the north of the Barossa Reservoir (Fig. 4).

6. *Callitris preissii*. Numerous small stands of this species occur on the shallow Eocene lacustrine sands in the Golden Grove and Barossa Goldfield areas (Figs. 3 and 4). In both areas the annual rainfall is about 25 inches.

B. *Species of the Dry Sclerophyll Forest*

1. *Eucalyptus fasciculosa* occurs in almost pure stands in the dry sclerophyll forest formation on the infertile Golden Grove lacustrine sands, the quartzitic soil of the Eden (Ansteys Hill) scarp, and the lateritic soils of the Barossa Goldfields. Above a rainfall of 30 inches per annum, the species is intermixed with *E. elaeophora* and *E. obliqua*. In the wettest locality east of Mount Gawler (approximately 36 inches per annum) the species is only a minor component in the exposed habitats of the *E. obliqua* forest.

This distribution is similar to that observed by Specht and Perry (1948) to the south of the Torrens Gorge.

2. *Eucalyptus baxteri* was found by Specht and Perry (1948) to occupy only the most impoverished soils where the rainfall was above 30 inches per annum. Such habitats are rare north of the Torrens Gorge. One small area of lacustrine sandstone is found on the eastern slopes of Mount Gawler; the Tanunda Creek granites are also very low in nutrients. *E. baxteri* is found on both these sites (Fig. 1), and, as yet, has not been recorded anywhere else in the dry sclerophyll forest of this area.

The disjunct distribution of this species is of note: Black Hill, Mount Gawler, Tanunda Creek.

3. *Eucalyptus obliqua*, noted by Specht and Perry (1948) as being present only above 33 inch isohyet (widespread above 35 inches per annum) on infertile soils, occupies similar habitats on the Archaeozoic rocks from the River Torrens south of Millbrook Reservoir to Mount Gawler. On the ridge to the west of Millbrook Reservoir and on the eastern slopes of Mount Gawler the species is almost the sole tree of the dry sclerophyll forest. Elsewhere, below 35 inches per annum, it is co-dominant with *E. elaeophora* and *E. fasciculosa*.

C. *Species of the Sclerophyll Shrub Woodland (Mallee)*

1. *Eucalytus odorata* var. *angustifolia* was recorded by Specht and Perry (1948) from two small areas on sandy, detrital soils at the foot of Black Hill. The same "whipstick mallee" is found in several stands in the Barossa Goldfields (Fig. 4), on sandy soils and almost identical rainfall (25 inches per annum).

2. *Eucalyptus gracilis.* This species, together with *Melaleuca uncinata*, is found on the solodic sands of Eocene lacustrine origin in the Barossa Goldfields (Fig. 4).

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FLORA CONSERVATION IN SOUTH AUSTRALIA
I. THE PRESERVATION OF PLANT FORMATIONS AND ASSOCIATIONS RECORDED IN SOUTH AUSTRALIA

BY R. L. SPECHT

Summary

The reasons for maintaining adequate flora reserves are examined from agricultural, economic, research, educational, aesthetic and historical points of view. The difficulties of maintaining these reserves against fires, contamination by agricultural fertilizers, invasion of weeds are discussed. The major flora reserves in South Australia are tabulated and the extent of preservation of the plant formations and associations recorded in this State is examined. The major deficiences in the present system of flora reserves are indicated,
VIZ.: -
(1) Coastal complex -mangrove vegetation
(2) Dry sclerophyll forest formation
(i) *Eucalyptus rubida* (candlebark gum) association
(ii) *E. cladocalyx* (sugar gum) association
(iii) *E. ovata* (swamp gum) - *Xanthorrhoea australis* association
(3) Savannah woodland formation
(i) *Casuarina luehmannii* (bull-oak) association
(ii) *Eucalyptus microcarpa* (box) association
(iii) *E. largiflorens* (river box) association
(iv) *Callitris propinqua* (native pine) association
(v) All other associations, although found on reserves, are in jeopardy from invading species.
(4) Tussock grassland formation
(i) *Gahnia trifida* (cutting grass) -*Cladium filum* (thatching grass) association.
(ii) *Lomandra dura-Lornandru multiflora* (iron grass) association
(5) Sclerophyllous mallee sub-formation-Form A (mallee-broombush)
(i) *Eucalyptus cneorifolia* (Kangaroo Island mallee) -*Melaleuca uncinata*(broombush) association
(6) Mallee sub-formation
(i) *Eucalyptus oleosa* (giant red mallee) -*E. pileata* (white mallee) association
(7) Low layered woodland (arid woodland) formation
(i) *Acacia sowdenii* (myall) association
(ii) *Acacia aneura* (mulga .) association
(iii) *Acacia brachystachya* (umbrella mulga) association
(iv) *Acacia linophylla* association
(v) *Eremophila-Dodonaea-Cussia* association
(8) Shrub steppe formation
(i) *Atriplex vesicaria* (bladder saltbush) association
(ii) *Kochia sedifolia* (bluebush) association
(iii) *Kochia astrotricha* (pearl bush) association
(9) Semi-arid tussock grassland
(i) *Astrebla* (Mitchell grass) association
(10) Desert zone complex

FLORA CONSERVATION IN SOUTH AUSTRALIA

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by R. L. SPECHT[1]

(*with collaboration from J. B. Cleland*[2])

(Read 10 August 1961)

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The major deficiences in the present system of flora reserves are indicated, viz.:—

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- (v) All other associations, although found on reserves, are in jeopardy from invading species.

(4) Tussock grassland formation
- (i) *Gahnia trifida* (cutting grass)—*Cladium filum* (thatching grass) association.
- (ii) *Lomandra dura-Lomandra multiflora* (iron grass) association

(5) Sclerophyllous mallee sub-formation—Form A (mallee-broombush)
- (i) *Eucalyptus cneorifolia* (Kangaroo Island mallee)—*Melaleuca uncinata* (broombush) association

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- (v) *Eremophila-Dodonaea-Cassia* association

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PART 1. REASONS FOR MAINTAINING ADEQUATE RESERVES

In the natural state, plants and animals live in a delicate balance with their environment. Any small change in environment will upset this balance and often lead to the partial or complete destruction of one or more of the component plants or animals of the community. Scientists now refer to this complex interrelationship between plants, animals, soils and climate as an ecosystem; they are just beginning to know a little about the delicate adjustments necessary to maintain the *status quo*. The plants, many different species each with its own preference for soil and micro-climate, are the key to the ecosystem; they produce foodstuffs from sunlight, foodstuffs not only necessary for themselves but (1) for all the bacteria, fungi, worms and microscopic organisms of the litter and soil, (2) for all the animals and birds which browse on the plants or sup nectar from their flowers. All are dependent the one on the other; upset one, upset the whole ecosystem – often even the soil structure and fertility will be subtly changed. Change the environment by either slightly altering (1) the soil fertility or (2) amount of soil moisture, and many of the original plants will fail to survive. They may be replaced by alien introductions, usually weeds or foreign grasses and herbs. The whole ecosystem can be disrupted by introduced birds and animals which kill out native plants and animals.

Within the limits of our knowledge – which, in many cases, is extremely shallow – we could preserve many of our native plants in Botanic Gardens, our larger animals and birds in Zoological Gardens. But our Botanic Gardens are far too small for such a programme, the Zoos cannot hope to preserve the multitude of insects, spiders, worms, microscopic animals which abound in the field. Also Botanic Gardens and Zoological Gardens are not designed to preserve soils which, as mentioned above, are so delicately in equilibrium with the plant and animal communities.

The ecosystem (plant, animal, soil) can be preserved for posterity only in natural reserves.

If no such areas are preserved, our descendants will be deprived of the following:

(1) *Virgin Soils for Agricultural Research.*

The study of soil in its natural state enables an appreciation of the changes wrought by good or bad agriculture on its structure and fertility, e.g., the declining wheat yield in many parts of South Australia, in spite of fertilizers

Reserves on Eyre Peninsula:
1. Hd. Flinders
2. Hd. Lake Wangary
3. Hds. Hincks, Nicholls, Murlong and Out of Hundreds
4. Hds. Hambidge and Out of Hundreds
5. Hd. Minnipa
6. Pearson Islands

Reserves on Kangaroo Island:
7. Flinders Chase

Reserves in Mt. Lofty Ranges:
8. National Park, Belair
9. Obelisk Estate, Mt. Lofty Summit and Waterfall Gully
10. Horsnell Gully
11. Morialta Falls
12. Para Wirra National Park

Reserve in Mid-North:
13. Seven Hills

Reserves in Flinders Ranges:
14. Alligator Gorge, Mambray Creek
15. Wilpena Pound

Reserve in Arid North-East:
16. Koonamore Vegetation Reserve

Reserves in South-East:
17. Fairview Wild Life Reserve
18. Hds. Archibald, Makin

Reserves in Murray Mallee:
19. Hd. Billiatt
20. Hd. Peebinga
21. Chauncey's Line

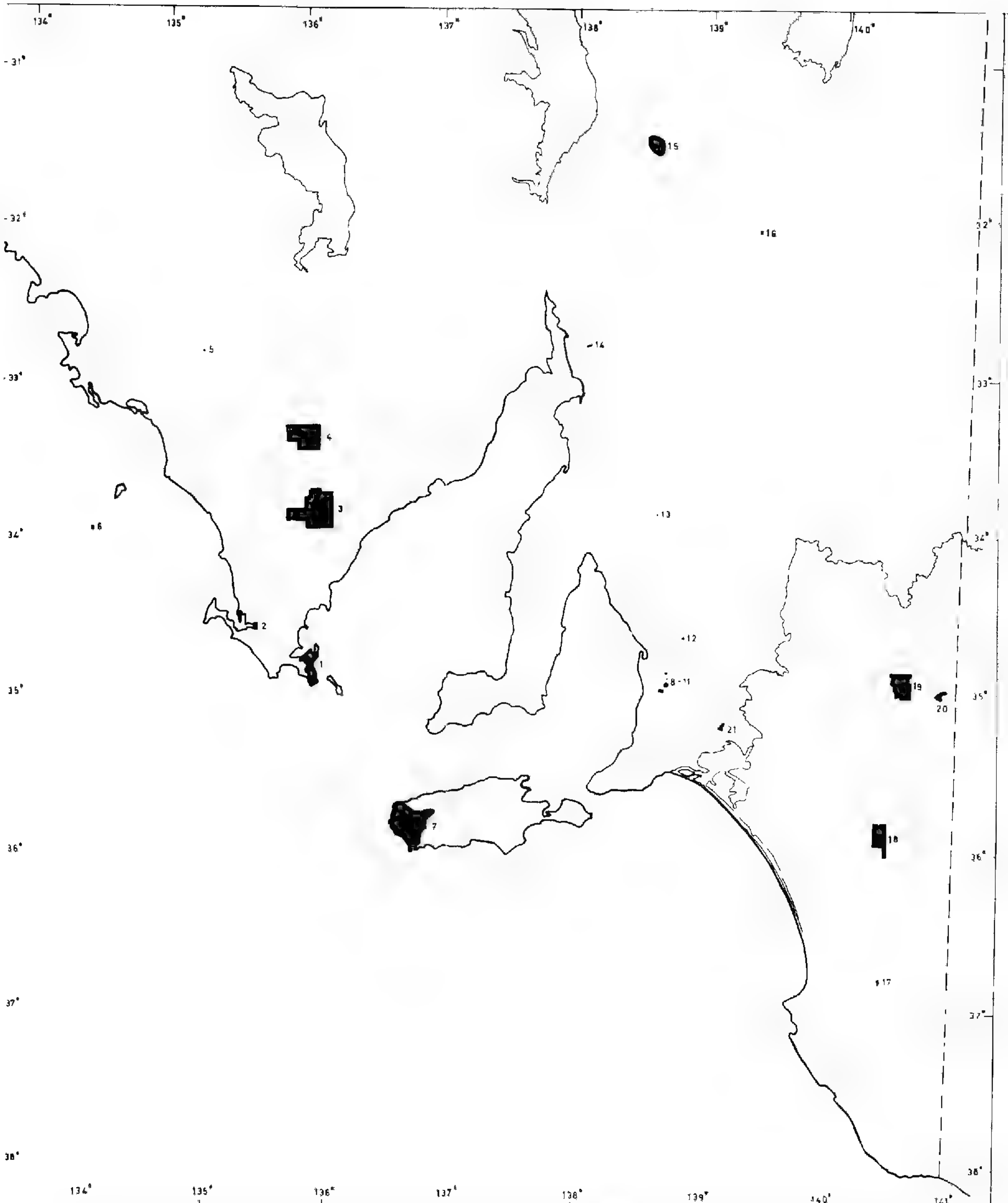

Fig. 1. Map of the Southern Portion of South Australia showing the Major National Parks and Reserves Preserving both Flora and Fauna.

(Cornish, 1949) may be due to a deterioration in soil structure. It is essential to have virgin soils for comparison to see where agriculture has gone wrong.

(2) *Sources of Economic Animals, Plants, Fungi and Bacteria.*

(a) Reserves provide a reservoir of seed of native plants which, now considered valueless, may eventually become valuable economic plants yielding drugs, rubber, oils, etc., e.g. *Duboisia*, a native Australian plant, yields the drugs hyoscyamine and hyoscine.

(b) A reservoir of fungi and bacteria which, like plants, can yield valuable drugs, e.g. *Penicillium.*

(c) A reservoir of insects which, in another environment, may control weeds or insect pests, e.g. *Cactoblastis* and prickly pear.

(3) *Opportunities for Ecological Research.*

Reserves afford the chance to understand the "web of life" — the ecosystem — results of which could have far-reaching effects on human geography.

(4) *Tertiary Educational Facilities.*

Reserves form an important training ground for university students in zoology, botany, agriculture and forestry, e.g. the Archibald-Makin, National Park, Belair, Obelisk Estate and Koonamore Vegetation Reserves are important training areas for botany, forestry and agricultural students at the present day — just as important as laboratory facilities at the University.

(5) *Aesthetic Appreciation of Nature.*

An appreciation of the wealth and beauty of our native flora and fauna is afforded by reserves.

(6) *Historical Studies.*

An appreciation of the trials faced by our early settlers in opening up the country can be quickly gained by a study of the original country.

Altogether, there are good scientific, economic, aesthetic and social reasons for preserving our native flora, fauna and soils. Australia is as yet a young country and the botanist, zoologist and soil scientist find themselves witnessing the destruction of the flora, fauna and soil before it has been satisfactorily studied and classified. Many problems, botanical, zoological and pedological have not yet been solved and many of these have an important bearing on the economy of the country.

Australia is in a unique position as regards Flora and Fauna conservation. It is the only continent where man did not develop agriculture or animal husbandry. The nomadic, hunting aborigines little disturbed the ecosystem. All other continents have suffered severely at the hand of man. And yet the appreciation of Australia's natural heritage, its preservation for posterity is continually bowing before the greed of man, his lust for a little more land to develop for pasture or crop and yet, though filling his pocket, scarcely improving the economy of Australia.

PART II. DIFFICULTIES OF MAINTAINING FLORA RESERVES

1. *Fire.*

Wanton firing of reserves often occurs under the pretext that—

(a) the reserve harbours vermin; and

(b) it is a potential fire hazard for neighbouring farms and houses.

At least in dry sclerophyll forest, sclerophyllous mallee and heath formations, the flora is fire resistant. In fact, the wealth of diverse species appears to

be maintained by irregular firing (Specht, Rayson and Jackman, 1958). However, too frequent firing can have the reverse effect because the regenerating species have not had time to set seed. The fire resistance of other communities has not been investigated.

2. *Effect of Fertilizers.*

The dry sclerophyll forest, sclerophyllous mallee and heath formations all occur on soils markedly deficient in phosphorus.

Fertilizers, especially superphosphate, have a marked effect on the vegetation of these deficient soils. Weed species from adjacent farmlands — seeds are often blown in from farms many miles away — can become established in the more fertile soil and compete vigorously with the native vegetation. The established native species grow vigorously on application of superphosphate and complete their life-cycle more rapidly, but are unable to re-establish themselves due to (a) the unfavourable "toxic effect" of the fertilizer on their seedlings, as well as (b) the competition from the alien weeds (Specht, in press, 1961). The native vegetation eventually disappears.

There is a danger that superphosphate spread either by super-spreaders or aerial top-dressing will influence the reserves, especially for some distance from their margins. Even dust storms blowing enriched soil from neighbouring farms onto the area will eventually affect the vegetation.

Fertilizers have similar effects on other plant formations. Alien plants have easily invaded the savannah woodland, tussock grassland and mallee formations, where the soil fertility is favourable to their growth. There many of the original native species can exist in competition with the aliens. However, as soon as fertilizers are applied, the aliens (many spring annuals) often grow faster than the native species and use up most of the soil moisture long before the native species can begin their summer growth and death inevitably results.

3. *Alien Species.*

These are almost impossible to exclude from any formations (see 2 above). Inevitably they alter the original structure and composition of the community.

4. *Rabbits.*

Rabbits are probably the worst vermin. This is especially obvious in the arid and semi-arid communities where regeneration of the native species is often precluded by rabbit plagues destroying all seedlings and ring-barking the adult plants (*vide* Koonamore Vegetation Reserve—Wood, 1936). It is essential to net and maintain reserves with rabbit-proof enclosures and, if possible, destroy all existing colonies of rabbits.

5. *Roads and Tracks.*

Roads and tracks through reserves, unless policed, enable illicit wood-cutting and collection of economic species (yielding essential oils, brush for fences, horticultural species, etc.). As well, illegal shooting is facilitated. The dumping of rubbish (a source of added fertility—see 2 above) invariably occurs.

General Remarks.

(a) Reserves should be fenced to exclude rabbits and other vermin.

(b) The ¼ to ½ mile around the edge should be considered as waste land — a "buffer zone" where the ecosystem may be disrupted by enriched dust, weeds and pests blown in from the neighbouring farms.

(c) Fires should be reduced to the minimum, not because of their effect on the flora, which is often fire resistant, but because of the destruction of the fauna, both large and small.

(d) Tracks and roads should be kept to a minimum and, if possible, policed.

PART III. MAJOR NATIONAL PARKS AND RESERVES PRESERVING FLORA IN SOUTH AUSTRALIA

(The distribution of these parks and reserves is indicated on the map of South Australia – Table 1)

Locality	Hundred	Section numbers	Area (acres)	Control
Eyre Peninsula				
1. County Flinders	Hd. Flinders	2, 3, 5, 6, 12-14	35,521½	Flora & Fauna Advisory Committee
2. County Flinders	Hd. Lake Wangary	1-13, 21, 131, 271, 273-7, 295	4,501½	Flora & Fauna Advisory Committee
3. County Jervois	Hd. Hincks	2	52,965	Flora & Fauna Advisory Committee
	Hd. Nicholls	11	29,620	Flora & Fauna Advisory Committee
	Hd. Murlong	25	7,130	Flora & Fauna Advisory Committee
	Out of Hundreds	365	73,610	Flora & Fauna Advisory Committee
4. County Jervois	Hd. Hambidge	7	38,950	Flora & Fauna Advisory Committee
	Out of Hundreds	364	54,915	Flora & Fauna Advisory Committee
5. County Le Hunte	Hd. Minnipa	94	40¼	Minister of Agriculture
6.**Pearson Islands, Investigator Group			4,160	Minister of Agriculture
Kangaroo Island				
Flinders Chase (County Carnarvon)	Hds. Gosse, MacDonald & Out of Hundreds	No section numbers	135,680	Fauna & Flora Board
Mount Lofty Ranges				
1. National Park, Belair (County Adelaide)	Hd. Adelaide	No section numbers, plus 567, 580, 979	2,243	Commissioners of National Park and Wild Life Reserves
2. Para Wirra National Park (County Adelaide)	Hd. Para Wirra	288, 289, part 3273, 3278, 3279	1,150	Commissioners of National Park and Wild Life Reserves
3.*Obelisk Estate (County Adelaide)	Hd. Adelaide	924, Pt925, Pt926, Pt931, 969, 983, 984, 985, Pt1053, Pt1054, 1115, Pt1160, Pt1161, Pt1172	1,753	Tourist Bureau

*Mt. Lofty Summit (County Adelaide)	Hd. Adelaide Hd. Onkaparinga	500 424	58	Tourist Bureau
*Waterfall Gully (County Adelaide)	Hd. Adelaide	920	103	Tourist Bureau
4.*Morialta Falls (County Adelaide)	Hd. Adelaide	Pt810, Pt822, 823, Pt850, Pt852, Pt853, Pt854, Pt855	539	Tourist Bureau
5.*Horsnell Gully (County Adelaide)	Hd. Adelaide	919, Pt1109, 1180, 1181	282	Tourist Bureau
Mid-North				
Seven Hills	Hd. Clare	568	14	Commissioners of National Park and Wild Life Reserves
Lower South-East				
Fairview Wild Life Reserve (County Macdonnell)	Hd. Woolumbool	98, south end of 93	2,600	Commissioners of National Park and Wild Life Reserves
Upper South-East				
County Buckingham	Hd. Archibald	9, 10	35,400	Flora and Fauna Advisory Committee
	Hd. Makin	3, 4	12,150	Flora and Fauna Advisory Committee
Murray Mallee				
1. Chauncey's Line (County Sturt)	Hd. Freeling	103, 238, 241, 242, 245, 246, 266-8, 271 and 272	2,000	Commissioners of National Park and Wild Life Reserves
2. County Chandos	Hd. Billiatt	15	56,000	Nil
3. County Chandos	Hd. Peebinga	21, 22, 30, 31	5,122	Nil
Flinders Ranges				
1.*Wilpena Pound (Counties Hanson & Taunton)	North Out of Hundreds	106	19,840	Tourist Bureau
2.*Mambray Creek Gorge (County Frome)	Hd. Baroota	PtM, PtN, PtQ, PtR	250	Tourist Bureau
*Alligator Gorge (County Frome)	Hd. Baroota	PtM, PtN, PtQ, PtR	25	Tourist Bureau
Arid N.E. South Australia				
Koonamore Vegetation Reserve (County Lytton)	North Out of Hundreds	304	960	University of Adelaide

** Officially only a Sanctuary for Animals and Birds, but so isolated from the mainland that the islands may be regarded also as a flora reserve.

* Officially termed National Pleasure Resorts, though, as yet, so little altered that they can still be classed as flora reserves. Many National Pleasure Resorts can no longer be regarded as flora reserves.

TABLE 2.

THE PRINCIPAL PLANT FORMATIONS PRESERVED IN FLORA AND FAUNA RESERVES IN SOUTH AUSTRALIA

(*This table includes all flora and fauna reserves enumerated in Table 1*)

Major Ecosystems	Soil	Approximate area* in South Australia (sq. miles)	Estimated area reserved (sq. miles)	Percentage reserved
Coastal complex				
(1) Dune vegetation	Coastal sand dune	?	2·7	?
(2) Salt marshes	Solonchak, etc.	?	3·6	?
Dry sclerophyll forest (stringybark forest)	Podsols, lateritic podsols, etc.	4,400	118·3	2·69
Savannah woodland (peppermint, blue, manna, red gum)	Red brown earths, terra rossas, grey soils of heavy texture, etc.	8,000	20·3	0·25
Tussock grassland				
(1) Cutting grass thatching grass	Flooded rendzinas (black soil plains)	700	Almost nil	Almost nil
(2) Iron grass	Skeletal soils on hillsides (Burra, Kaunantoo, etc.)	1,200	Nil	Nil
Mallee (Giant red mallee-white mallee, *E. oleosa-E. pileata*)	Brown solonized (mallee) soil	41,500	0·1	Almost nil
Sclerophyllous mallee A. (Desert mallee-broombush, *E. incrassata-Melaleuca uncinata*)	Solonized sands and sand dunes	11,000	384·4	3·49
Sclerophyllous mallee B. (Black mallee-scrub, *E. diversifolia*)	Shallow grey and red limestoney soils	5,000	276·6	5·53
Heath	Deep sand dunes or impoverished, water-logged sands	5,500	57·8	1·05
Low layered woodland	Desert loams and sand ridges, etc.			
(1) Myall		8,000	Nil	Nil
(2) Coolibah		2,500	Nil	Nil
(3) Mulga, black oak, false sandalwood		65,000	1·5	Almost nil
Shrub steppe (saltbush, bluebush, etc.)	Desert loams, etc.	67,200	Nil	Nil
Semi-arid tussock grassland (Mitchell grass)	Desert loams, etc.	39,500	Nil	Nil
Sclerophyll shrub savannah (*Cassia-Eremophila*, etc.).	Skeletal soils	22,000	27·9**	0·13
Desert complex (porcupine bush, sand deserts)	Stony and sandy deserts	89,500	Nil	Nil
Salt lakes		9,000	Nil	Nil
Total		380,000	893·2†	0·24

* Calculated from map by R. J. Williams (1955) "*Vegetation Regions of Australia.*"
** Estimate of the area covered by the vegetation on the sides of Wilpena Pound.
† Some 5,000 acres of miscellaneous vegetation on Flinders Chase and 700 acres of lagoon, etc. on Fairview Wild Life Reserve are not included in this total.

PART IV. THE PRESERVATION OF PLANT FORMATIONS AND ASSOCIATIONS RECORDED IN SOUTH AUSTRALIA

According to Wood in his chapter on "The Vegetation of South Australia" in "Introducing South Australia" (1958), the vegetation of this State may be considered under the following sub-divisions:

1. Coastal complex.
2. Dry sclerophyll forest formation.
3. Savannah woodland formation.
4. Tussock grassland.
5. Sclerophyllous mallee (mallee-broombush), mallee-heath and heath sub-formations.
6. Mallee sub-formation.
7. Low layered woodland (arid woodland).
8. Shrub steppe.
9. Desert complex.

1. The Coastal Complex.

(1) *Description.*

The coastline of South Australia consists of sand dunes, mud flats and cliffs, each with its characteristic vegetation.

The pioneer plant on the seaward side of unstable dunes is a creeping grass, *Spinifex hirsutus,* which binds the soil sufficiently to allow rushes, chiefly *Scirpus nodosus* and *Lepidosperma gladiatum,* to colonize the dune faces. These stabilize the soil and provide sufficient humus for a composite shrub (*Olearia axillaris*) to establish itself, and a shrubland is eventually established in which common plants are *Acacia sophorae* (coastal wattle), *Myoporum insulare* (boobyalla) and *Leucopogon parviflorus.*

On mud flats the mangrove, *Avicennia marina* var. *resinifera,* may occur within the limits of daily tidal scour with salt marsh showing zonation beyond. Two dwarf shrublands of samphires occur with decreasing salt content, dominated respectively by *Arthrocnemum arbuscula* and *Arthrocnemum halocnemoides.* With rising level of the swamp and consequent decrease in salt content these are replaced successively in some districts by communities dominated by the salt grasses *Sporobolus virginicus* and *Distichlis spicata,* and in other districts by the saltbush, *Atriplex paludosa.* In semi-saline swamps near the mouths of freshwater rivers, *Melaleuca halmaturorum* (paper-bark tea-tree), forms a fringing forest, and with decreasing salt content a zonation occurs in which the chief species are successively *Salicornia australis* (samphire) and *Suaeda australis, Juncus maritimus* (rush), *Selliera radicans* and *Distichlis spicata.*

(2) *Preservation.*

(i) *Coastal dune vegetation.* Aerial photographs of the reserve in the Hundred of Flinders indicate that approximately 1,750 acres of coastal dune are preserved along its southern boundary.

One hopes that the disputed Younghusband Peninsula on the seaward side of the Coorong, the waters of which are already a Bird Sanctuary, will eventually be included as a Reserve. This area of coastal dune, almost untouched, affords a unique comparison with the dunes preserved on Eyre Peninsula as well as in eastern and western Australia, with which there are considerable floristic differences.

(ii) *Coastal cliff vegetation* is satisfactorily preserved in Flinders Chase (Kangaroo Island), Hd. Flinders (Eyre Peninsula), and Pearson Islands (Eyre Peninsula).

(iii) About 2,000 acres of samphires and related vegetation (especially *Atriplex paludosa* and *Melaleuca halmaturorum*) are preserved on the Pearson Islands (Eyre Peninsula); another 320 acres are preserved on the Fairview Wild Life Reserve.

(iv) The mangrove (*Avicennia*) is nowhere preserved.

(3) *References.*

Osborn (1923), Osborn and Wood (1923), Wood (1937), Fenner and Cleland (1935), Crocker (1944), Rix (private communication, 1961).

2. Dry Sclerophyll Forest Formation.

(1) *Description.*

This is a community of plants dominated by trees of forest form, i.e. with flat crowns and with bole usually greater in height than the depth of the crown, the crowns mainly continuous. A well-developed layer of shrubs is present but grasses and herbs are rare or absent.

Dry sclerophyll forest occurs in the wettest parts of the Mt. Lofty Ranges and in the South-East and in more restricted localities in the southern Flinders Ranges, in Southern Eyre Peninsula and on Kangaroo Island on acidic, usually podsolized soils, low in nutrient status, especially in phosphorus, and sometimes low in copper, zinc, molybdenum and potassium. The chief dominants are the stringybarks, *Eucalyptus obliqua* (messmate) and *Eucalyptus baxteri* (brown stringybark), the former occurring in wetter habitats with slightly higher nutrient status than the latter in the Mt. Lofty Ranges, the South-East and Kangaroo Island. *Eucalyptus elaeophora* (bastard box) occurs on podsolized soils in the Mt. Lofty and Flinders Ranges; *Eucalyptus fasciculosa* (pink gum) occupies the driest portion of the dry sclerophyll forest zone. *Eucalyptus cladocalyx* (sugar gum) is the dominant on Eyre Peninsula and in parts of the Flinders Ranges and Kangaroo Island; *Eucalyptus cosmophylla* (cup gum) is more light-demanding than other forest dominants in the Mt. Lofty Ranges and on Kangaroo Island.

The chief undershrubs vary from place to place, independently of the tree species, in response to changes in the micro-habitat and previous history. The characteristic species are *Acacia myrtifolia* (wattle), *Pultenaea daphnoides* (native broom), *Xanthorrhoea semiplana* (grass tree), *Leptospermum scoparium* (tea tree), *Epacris impressa* (heath) and *Hakea rostrata* (needlebush).

Aliens are few in these closed communities, but in the Mt. Lofty Ranges *Cytisus canariensis* (broom) and *Ulex europaeus* (gorse) are common along roadsides.

(2) *Preservation.*

Approximately 3,000 acres of dry sclerophyll forest formation are preserved in the Mt. Lofty Ranges (all five reserves); possibly half of Flinders Chase,* 70,000 acres, supports this formation; 1,400 acres are found on Fairview Wild Life Reserve, at least 1,000 acres on the Hundreds Archibald-Makin Reserve and 14 acres at Seven Hills. A small area may be present in the Alligator Gorge Reserve. In all, about 75,700 acres of this formation may be preserved in South Australia.

(i) *Eucalyptus rubida* association, a relic community, is preserved only at the eastern edge of the Obelisk Estate. In this area it is in great danger of extinction from roadside invaders.

* Unfortunately, this estimate must be regarded with suspicion until an ecological survey has been made of this important reserve.

(ii) *Eucalyptus obliqua* dominated associations (may have *E. baxteri*, *E. cosmophylla*, *E. fasciculosa* or *E. elaeophora* as co-dominant trees).

These communities are found in reserves in the Mt. Lofty Ranges (viz. Belair National Park, Obelisk Estate, Morialta), as well as in limited areas on Flinders Chase. Mixed communities of *E. obliqua* and *E. elaeophora*, north of the Torrens Gorge, are not preserved. The relic tree-fern, *Todea barbara*, and associated swamp flora are preserved on Obelisk Estate.

(iii) *Eucalyptus baxteri* dominated associations (may have *E. obliqua*, *E. viminalis* var. *huberiana*, *E. cosmophylla*, *E. diversifolia* as co-dominant trees).

These associations are found in reserves in Mt. Lofty Ranges (Obelisk Estate and Morialta), Flinders Chase, north-east of Keith (Archibald-Makin Reserve), and on Fairview Wild Life Reserve.

(iv) *Eucalyptus fasciculosa* dominated associations (may have *E. baxteri*, *E. elaeophora* or *E. leucoxylon* as co-dominant trees) are found in reserves of Mt. Lofty Ranges (Belair National Park, Morialta and Para Wirra), and in reserve near Keith (Hd. Archibald-Makin), possibly Flinders Chase, and on Fairview Wild Life Reserve.

(v) *Eucalyptus elaeophora* dominated associations (may have *E. fasciculosa*. *E. obliqua* or *E. cladocalyx* as co-dominant trees).

These associations are preserved only on the Para Wirra Reserve of Mt. Lofty Ranges; they may be present in Mambray Creek-Alligator Gorge Reserves of Lower Flinders Ranges.

(vi) *Eucalyptus cladocalyx* dominated associations (may have *E. elaeophora* as co-dominant tree).

This tree is found in both dry sclerophyll forests and savannah woodland formations. It occurs in the latter formation on Flinders Chase.

The dry sclerophyll forest formation of *E. cladocalyx* occurs in the Lower Flinders Ranges (doubtfully preserved in Mambray Creek-Alligator Gorge area) and Lower Eyre Peninsula (no reserve).

(vii) *Eucalyptus macrorrhyncha* association.

This eastern Australian species occurs in a relic stand near Seven Hills. Fourteen acres of the stand are preserved on Section 568, Hundred of Clare.

(viii) *Eucalyptus ovata-Xanthorrhoea australis* association.

The association found in the Lower South-East is not preserved.

Eucalyptus ovata probably occurs in Flinders Chase.

(3) *References.*

Adamson and Osborn (1924), Wood (1930), Wood (1937), Baldwin and Crocker (1941), Crocker (1944), Boomsma (1946), Crocker (1946a), Specht and Perry (1948), Boomsma (1949), Masterman (1950), Coaldrake (1951), Specht (1953), Rayson (1957), French (1958), Smith (1960), Martin (1961), Specht, Brownell and Hewitt (1961), Rix (private communication, 1961).

3. SAVANNAH WOODLAND FORMATION.

(1) *Description.*

Savannah woodland is dominated by trees of woodland form, i.e. with rounded crowns and with boles in which the height is usually less than the depth of the crown. The crowns are not continuous, but tree distribution is mid-dense to open. Small trees and shrubs are poorly developed or absent, but a herbaceous stratum in which grasses are prominent is well developed. Geophytes (plants perennating by means of underground organs) are seasonally prominent.

The woodlands occur on a variety of soils, characteristically on red-brown earths and terra rossas, but also sometimes on clay podsols, slightly higher in nutrient status than those carrying dry sclerophyll forest. The relatively high nutrient requirements of grasses (e.g. cereals) are well known. In the Mt. Lofty Ranges division between dry sclerophyll forest on soils derived from quartzites or laterites and savannah woodland on soils derived from slates and phyllites is frequent and sharp. The vegetation of the Adelaide Plains was originally savannah woodland.

The dominant tree species in South Australia, in order of increasing available water in the soil, are *Casuarina stricta* (sheoak), *Eucalyptus odorata* (peppermint), *Eucalyptus leucoxylon* (blue gum), *Eucalyptus camaldulensis* (red gum) and *Eucalyptus viminalis* (manna gum).

Native grasses were originally present, chiefly species of *Danthonia* (wallaby grasses) and *Themeda australis* (kangaroo grass), but have mostly disappeared under grazing or under competition by more aggressive introduced grasses chiefly from the Mediterranean region.

Especially in the Mt. Lofty Ranges, these open woodlands have been invaded by alien shrubs, which tend to alter the original open facies of the communities. The chief alien shrubs are *Olea europea* (olive), *Chrysanthemoides monilifera* (a yellow flowered composite from South Africa) and *Lavandula stoechas* (lavender).

(2) *Preservation.*

About 2,800 acres of savannah woodland are preserved in the Mt. Lofty Ranges, some area being present on each of the reserves. However, as this formation is (a) easily developed for tourist facilities and (b) readily invaded by introduced plants, the preservation of the formation in this area appears doomed to failure.

Much of the Mambray Creek-Alligator Gorge area (about 200 acres) is covered by this formation, also the basin of Wilpena Pound (possibly 2,000 acres). The formation is nearer its natural state in these two reserves than in any others.

About 7,000 acres of the formation is found on the reserves on Eyre Peninsula — 4,000 acres in Hd. Lake Wangary, 2,000 acres on Pearson Island and possibly 1,000 acres in Hd. Flinders. These reserves are located on the drier limit of the range of the savannah woodland formation; the vegetation (*Casuarina stricta-Melaleuca pubescens* association) is by no means typical, as it becomes more scrubby and merges into sclerophyllous mallee formation.

(i) *Eucalyptus camaldulensis* association is found on reserves in Mt. Lofty Ranges (Belair National Park, Obelisk Estate, Para Wirra), Wilpena Pound and Mambray Creek.

(ii) *Eucalyptus leucoxylon-E. viminalis* association is found on reserves of Mt. Lofty Ranges (Belair National Park, Obelisk Estate, Morialta, Para Wirra).

(iii) *Eucalyptus odorata* association (and related association of *E. calcicultrix* and *E. microcarpa*) occurs on reserves in Mt. Lofty Ranges (Belair National Park and Morialta).

No reserve contains the box (*E. microcarpa*) found in the Lower Flinders Ranges.

(iv) *Casuarina stricta-Melaleuca pubescens* association is preserved on Eyre Peninsula (Hd. Flinders, Hd. Lake Wangary and Pearson Islands).

(v) *Eucalyptus cladocalyx* association is preserved on Flinders Chase.

(vi) *Casuarina luehmannii* association.

This community is found on the grey soils of heavy texture, east of Bordertown and Frances. It is preserved neither in South Australia nor in the eastern States where it is more widespread.

(vii) *Eucalyptus largiflorens* association.

The river box is not protected in South Australia — except possibly in small Bird Sanctuaries along the River Murray.

(viii) *Callitris propinqua* association.

Probably not protected anywhere in South Australia.

(ix) *Callitris glauca* association.

Occurs in the Flinders Ranges (on Wilpena Pound and Mambray Creek reserves).

(3) *References.*

Osborn (1923), Adamson and Osborn (1924), Wood (1930), Wood (1937), Baldwin and Crocker (1941), Crocker (1944), Boomsma (1946), Jessup (1946), Tiver (1946), Specht and Perry (1948), Boomsma (1949), Boomsma (1950), Specht (1951), Specht (1953), French (1958), Lothian (1960), Smith (1960), Specht, Brownell and Hewitt (1961).

4. TUSSOCK GRASSLAND FORMATION.

(1) *Description.*

(i) *Gahnia trifida-Cladium filum* association on Rendzina Plains of Lower South-East. This tussock grassland (or actually a sedge land) may be an artifact produced by man. Formerly the low tree, *Banksia marginata,* appeared to be common over these plains. Now large tussocks of cutting grass (*Gahnia*), thatching grass (*Cladium*) and the white tussock grass (*Poa caespitosa*) are frequent in poorly drained and unploughed parts of the plains.

(ii) *Lomandra dura-Lomandra multiflora* (irongrass) association.

This tussock grassland (actually not a grass but a member of the family Liliaceae) is widespread in the severely frost affected highland country from near Burra to Peterborough. The community extends southward in small areas on the eastern side of the Mt. Lofty Ranges as far south as Langhorne Creek. In most areas, and particularly in the south, it grades into the *Casuarina stricta* savannah woodland. *Casuarina* may have been more widespread over the *Lomandra* stands before settlement, although early records are consistent concerning the treeless nature of the country.

(2) *Preservation.*

The *Gahnia-Cladium* association is found in limited areas on reserves in Hds. Flinders and Lake Wangary (Eyre Peninsula). Only a small area (on Fairview Wild Life Reserve) of this association is preserved in the Lower South-East, where it formerly occupied most of the Rendzina Plains.

The *Lomandra* association, although very extensive, is not preserved.

(3) *References.*

Wood (1937), Crocker (1944), Stephens *et al.* (1945), Jessup (1946), Jessup (1948).

5. SCLEROPHYLLOUS MALLEE — FORM A (*Mallee Broombush*), *Mallee Heath and Heath Sub-formations.*

(1) *Description.*

These three vegetation sub-formations are best considered together, though their structure varies. They occur in the Upper South-East, on Eyre Peninsula and on Kangaroo Island, but the best known occurrence is in the Coonalypn

Downs in the first-named area, where the communities, especially mallee broombush, are being replaced by extensive pasture development.

The soils consist of varying depths of sand over a solonized clay. As the depth of sand changes so does the available water status of the soils and the plant communities show a concomitant gradation. Mallee broombush occurs when the sand is less than 18 inches deep; as the sand deepens beyond 18 inches, heath elements become prominent until Mallee heath is general at a depth of 30 inches. When the sand is more than 48 inches deep, the mallee disappears and heath alone continues. These plant communities, with their accompanying soils, form a complex repetition pattern over large areas.

Mallee broombush is a vegetation type dominated by low trees of *Eucalyptus* species, with many stems arising from an underground root stock ("Mallees") and with a mid-dense layer of sclerophyllous leaved shrubs. The dominant species is *Eucalyptus incrassata*, which occurs in clumps, but on Kangaroo Island *Eucalyptus cneorifolia* (a main source of local *Eucalyptus* oil) is locally dominant. The chief shrub is *Melaleuca uncinata* (broombush), but other sclerophyllous species occur beneath them with rather open spacing. In drier regions, *Callitris verrucosa* and *C. canescens* (sand pines) are commonly found with *Melaleuca uncinata*.

Mallee heath and heath consist of very dense assemblages of sclerophyllous shrubs and undershrubs, many with heath-like leaves, varying in height from 1-5 feet. These communities are rich in species, but the dominants are *Banksia ornata*, *Casuarina pusilla* (sheoak) and *Xanthorrhoea australis* (grass tree). In mallee heath, *Eucalyptus leptophylla* occurs in scattered clumps.

(2) *Preservation.*

(i) *Sclerophyllous mallee*—Form A (mallee broombush).

This sub-formation has distinctive, but allied, associations in its widespread geographical localities, viz.:

(a) *E. incrassata-E. leptophylla-Melaleuca uncinata* association in the Upper South-East, with *Callitris verrucosa* co-dominant in drier areas towards the River Murray.

(b) *E. incrassata-E. leptophylla-E. flocktoniae-Melaleuca uncinata* association in Eyre Peninsula: with *Callitris verrucosa* co-dominant in drier areas.

(c) *E. flocktoniae-E. dumosa-Melaleuca uncinata* association in Eyre Peninsula.

(d) *Eucalyptus cneorifolia-Melaleuca uncinata* association on Kangaroo Island.

The first association occurs in the reserve north-east of Keith (4,000 acres in Hds. Archibald-Makin) and again on Chauncey's Line reserve (2,000 acres). The drier form of the association (with *Callitris verrucosa*) is common in the reserves in Hds. Peebinga and Billiatt (5,000 and 56,000 acres respectively).

The second and third associations are preserved in the two large reserves in C. Jervois, Eyre Peninsula (85,000 acres in Hds. Hincks-Murlong, etc., and 94,000 acres in Hds. Hambidge, etc.).

The fourth association, containing the characteristic Kangaroo Island mallee (*E. cneorifolia*), is not protected.

(ii) *Mallee Heath* (*Eucalyptus leptophylla—heath*).

Preserved in reserve north-east of Keith (2,000 acres).

(iii) *Heath.*

Various forms of this treeless sub-formation exist:

(a) The reserve north-east of Keith contains *Xanthorrhoea australis* and *Banksia ornata-Casuarina pusilla* type (37,000 acres).

(b) Areas of *Casuarina muelleriana-Leptospermum coriaceum* type are found in both reserves in County Jervois (Eyre Peninsula).

(c) A heath growing on salty flats, *Melaleuca gibbosa-Hakea rugosa* (with or without the sedge *Cladium filum*), is preserved on Fairview Wild Life Reserve in the South-East (230 acres).

(3) *References.*

Wood (1930), Wood (1937), Baldwin and Crocker (1941), Crocker (1944), Crocker (1946a), Jessup (1946), Northcote and Tucker (1948), Coaldrake (1951), Specht (1951), Specht and Rayson (1957), Rayson (1957), French (1958), Smith (1960), Rix (private communication, 1961).

6. Sclerophyllous Mallee — Form B.

(1) *Description.*

Two associations dominated by low, mallee-like trees of *Eucalyptus cosmophylla*, *E. diversifolia* and allied species (*E. rugosa*, *E. conglobata*, *E. baxteri*) are intermediate between the dry sclerophyll forest and sclerophyllous mallee (Form A). Understorey species common to each of these formations may be present in this sub-formation.

(2) *Preservation.*

The *E. cosmophylla* communities are preserved on Flinders Chase and Belair National Park; the *E. diversifolia* communities on three reserves on Eyre Peninsula (33,000 acres in Hd. Flinders, a small area in Hd. Lake Wangary, 78,000 acres in Hd. Nicholls and Section 365, Out of Hundreds of County Jervois), about 60,000 acres in Flinders Chase and 4,000 acres in the reserve north-east of Keith (Hd. Archibald-Makin).

The record (Lothian, 1960) of *Eucalyptus diversifolia* for the side walls of Wilpena Pound, Flinders Ranges, should be corrected to *E. morrisii*.

(3) *References.*

Adamson and Osborn (1924), Wood (1930), Wood (1937), Baldwin and Crocker (1941), Crocker (1944), Crocker (1946a), Jessup (1946), Specht and Perry (1948), Northcote and Tucker (1948), Masterman (1950), Coaldrake (1951), Specht (1951), Specht (1953), French (1958), Smith (1960).

7. Mallee Sub-formation.

(1) *Description.*

Mallee consists of eucalypts of mallee habit but with a discontinuous shrub layer, sometimes very open, and with a ground layer, which is seasonal, of grasses, annuals and ephemeral plants.

The chief species towards the wetter side of its range are *Eucalyptus anceps* and *Eucalyptus dumosa*, and towards the drier side, *Eucalyptus oleosa* and *Eucalyptus gracilis*. *Melaleuca pubescens* (black tea tree) also occurs, and when the soils are lighter and deeper *Callitris propinqua* (native pine) occurs. In the wetter range the shrubs are sclerophyllous (*Acacia* spp. being prominent), but towards the drier range the shrubs have hairy, semi-succulent leaves, the chief being species of *Atriplex* (salt bushes) and *Kochia* (blue bushes). Essentially, the mallee is transitional between the sclerophyllous leaved communities of the south and the semi-succulent leaved, chenopodiaceous communities of arid Australia.

Mallee occurs on soils alkaline in reaction, containing large quantities of limestone, often as rubble or as sheet travertine, and with heavy sub-soils with exchangeable sodium in the clay – a brown, solonized (mallee) soil.

Much of the winter cereals (especially wheat) is grown on soils which originally carried mallee or savannah woodland.

(2) *Preservation.*

Although this formation is more characteristic of South Australia than most other States, no adequate reserve has been proclaimed.

Small reserves such as (a) Coronation Park, Moorlands; (b) Folland Park, Enfield; (c) Minnipa Research Station (40 acres) have been created, but have invariably been damaged by Highways Department camps, pre-school kindergartens, as a stock-shelter, as well as by the inevitable invasion of weeds and rabbits.

A small area (Prominent Hill) in Section 364, Out of Hundreds, Eyre Peninsula, is the only stand of this mallee sub-formation which is satisfactorily reserved away from these contaminating influences. It should be preserved intact and undisturbed, if possible.

(3) *References.*

Wood (1929), Wood (1937), Boomsma (1946), Crocker (1946a), Jessup (1946), Jessup (1948), French (1958).

8. Low Layered Woodland (Arid Woodland).

(1) *Description.*

Low layered woodland consists of communities dominated by low trees or tall shrubs varying in spacing from dense to open; a low shrub stratum is usually present, rarely continuous but sometimes absent; the shrubs may be either sclerophyllous or with hairy, semi-succulent leaves. A herbaceous layer of perennial grasses may be present and seasonal herbs and ephemerals are usually well developed, but may sometimes be absent under dense canopies.

The chief dominants concerned are *Myoporum platycarpum* (false sandalwood), *Acacia sowdenii* (myall), *Casuarina cristata* (black oak), *Heterodendron oleifolium* (bullock bush), *Acacia aneura* (mulga), various other *Acacia* species and various species of *Eremophila* (native fuchsias), *Dodonaea* (hop bushes), and *Cassia* (kangaroo bushes).

Myoporum platycarpum and *Acacia sowdenii* occur at the southern limits of the area, at first admixed with mallee; the former is restricted to the east and the latter to the west of the Flinders Range. Both occur on loams containing varying amounts of limestone and are associated typically with a bluebush (*Kochia sedifolia*) and saltbushes (*Atriplex stipitata* and *Atriplex vesicaria*); *Cassia sturtii* and *Cassia eremophila* (kangaroo bushes) are frequently important shrubs.

Casuarina cristata and *Heterodendron* may occur with the same genera as the foregoing, but also with another bluebush (*Kochia astrotricha*) on soils with little lime in the profile, and also on sandhills and sandplain where they are not associated with bluebushes or saltbushes but chiefly with annuals and ephemerals. The mulga (*Acacia aneura*) shows a similar pattern of distribution and of variety of associated plants; in addition, it may occur on rocky hills associated with sclerophyllous shrubs. Other *Acacia* species, e.g. *Acacia brachystachya* and *Acacia linophylla* are dominant on sandhills, both with and without mulga. On rocky hills species of *Eremophila, Dodonaea* and *Cassia* may be dominants in low shrub-woodlands.

(2) *Preservation.*

Apart from the small Koonamore Vegetation Reserve of the University of Adelaide (960 acres), which preserves communities of—

(i) *Myoporum platycarpum-Atriplex vesicaria/A. stipitata*;
(ii) *Casuarina cristata-Atriplex stipitata*;
(iii) *Acacia aneura*;
(iv) Small stands of *Heterodendron oleifolium*;
(v) *Acacia Burkittii-Eremophila scoparia*,

none of the widespread "low layered woodlands" of South Australian arid areas are preserved.

(3) *References.*

Osborn, Wood and Paltridge (1935), Wood (1936), Wood (1937), Crocker and Skewes (1941), Jessup (1948), Jessup (1951).

9. Shrub Steppe Formation.

(1) *Description.*

Shrub steppe consists of communities of low shrubs with semi-succulent, usually hairy leaves, the plants separated by a distance about equal to the diameter of the bush. Perennial grasses may be present and ephemerals are prominent seasonally.

The chenopodiaceous shrubs mentioned in the last formation often cover areas in which trees are rare or absent; these areas are sometimes extensive, as in the Nullarbor Plain, or more frequently smaller, interspersed with various forms of low layered woodland.

The most important bluebushes are *Kochia sedifolia*, usually where limestone is close to the surface, and *Kochia astrotricha* where there is less lime in the soil. The most widespread saltbush is *Atriplex vesicaria*, of which several ecotypes, or "strains", occur, some occurring on calcareous soils, whilst others are found on soils with much less lime, e.g. on hill slopes or on silty flood plains. Various species of *Bassia* (bindyis) are commonly associated with them. After rains a wealth of composites, crucifers, legumes and grasses occurs. The perennial members of the shrub steppe, as also when they occur in low layered woodland, form a valuable fodder reserve for sheep in times of drought; in good seasons the annual plants of the woodlands or water courses are the preferred food.

On heavy soils, frequently gibber-coated, between the deserts a modified form of shrub steppe occurs mixed with areas of Tussock Grassland in which *Astrebla* species (Mitchell grasses) occur.

(2) *Preservation.*

Apart from about two acres of *Kochia sedifolia* association on Koonamore Vegetation Reserve, there are no areas in South Australia preserving any of these arid plant associations.

(3) *References.*

See Low Layered Woodland above.

10. Desert Zone Complex.

(1) *Description.*

Desert regions occur when evaporation is greater than precipitation during each month of the year. They present a complicated mosaic of plant communities. Sandy deserts consist of long, parallel sand-ridges with an approximately constant repetition pattern. Both dunes and interdunal corridors are vegetated.

The dunes typically carry *Zygochloa paradoxa* (cane grass) on the crests and *Triodia basedowii* (spinifex) on the lower ridge slopes and on sandy inter-dune corridors; small shrubs like *Hakea leucoptera* (needlebush) and species of *Grevillea* and *Eremophila* occur in sandy hollows. Shrub steppe occurs on clayey-interdunal corridors. A restricted ephemeral flora of crucifers and grasses is prominent seasonally.

(2) *Preservation.*
No reserve in South Australia.

(3) *References.*
Crocker (1946b), Jessup (1951).

V. GENERAL CONCLUSIONS

It should be the duty of each State to ensure that every major *plant formation* and, if possible, *every species* within its boundaries is preserved for posterity. Table 2 indicates the situation in the State of South Australia.

It is obvious that there are glaring deficiencies in reserves in South Australia. It is fortunate that in most cases it is not too late to amend this situation.

These reserves would not necessarily be tourist attractions like the Barrier Reef, Ayers Rock, the Grampians, but would have far more merit scientifically, economically, aesthetically and socially. They would cover not only our waste and arid lands, but examples of our first-class country as well. If they came to pass, future generations both in South Australia and all over the world would be high in their praise of the foresight of today's administration. Theodore Roosevelt had this wisdom in the United States. It is now up to our administration to act before it is too late.

The policy of the near future should be to concentrate on finding, against the background of Table 2 data, which vegetation communities are in danger of extinction, and to recommend reserves in areas where they still exist. In certain cases there is clearly less urgency (e.g. regarding reserves of the Desert Complex), but complacency should be avoided. The early formulation of a longer range detailed policy and its implementation are, of course, highly desirable.

The present difficulty is to make specific recommendations. Although detailed descriptions of the distribution of the flora are now available, there is as yet no corresponding list of *specific* areas which need complete protection in order to rectify the deficiencies revealed in Table 2. Such a survey is urgently required as the next step in Flora Conservation in South Australia.

VI. ACKNOWLEDGMENTS

This study was undertaken to provide background information for several bodies interested in flora conservation in this State, namely:

(a) National Parks and Reserves Sub-Committee for South Australia for the Australian Academy of Science;

(b) Flora and Fauna Investigation Committee.

The co-operation of fellow members of these bodies is gratefully acknowledged.

Information on some reserves, especially Flinders Chase, Kangaroo Island, and the reserve in Hundred of Flinders, Eyre Peninsula, is somewhat meagre. Detailed information on other reserves was available in published records or our own notes. Mr. C. E. Rix of the Department of Lands, South Australia, provided information on Fairview Wild Life Reserve; Mr. D. E. Symon, of the Waite Agricultural Research Institute, information on Wilpena Pound.

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SOME MEDUSAE FROM NORTHERN AUSTRALIA

BY P. L. KRAMP

Summary

A collection of Australian medusae has been sent to me from the South Australian Museum. With one exception (*Solmundella bitentaculata*) these medusae were collected at the Great Barrier Reef, North Queensland, between 20 Dec. 1958 and 19 Feb. 1959, and the collection was accompanied by notes on the appearance and behaviour of the living specimens and the conditions under which the catches were made. In the following account I take great pleasure in quoting these valuable and interesting observations, which were made by Dr. J. H. Barnes during his excursions among the islands of the Great Barrier Reef. On a previous occasion I have dealt with the Hydromedusae of the Great Barrier Expedition, 1928-29 (Kramp, 1953). For morphological and taxonomic discussions, as also for references to the literature, I refer to that paper, though some additional remarks will be found in the following account. The present collection contains 13 species of Hydromedusae and three species of Scyphomedusae. Only one of the species has not previously been observed in Australian waters; it is described below as a new species, Melicertissa orientalis nsp, I am greatly indebted to Dr. R. V. Southcott, of the South Australian Museum, because he has sent me this interesting collection.

SOME MEDUSAE FROM NORTHERN AUSTRALIA

by P. L. Kramp
(Zoological Museum, Copenhagen)
(*Communicated by R. V. Southcott*)

(Read 14 September 1961)

INTRODUCTION

A collection of Australian medusae has been sent to me from the South Australian Museum. With one exception (*Solmundella bitentaculata*) these medusae were collected at the Great Barrier Reef, North Queensland, between 20 Dec. 1958 and 19 Feb. 1959, and the collection was accompanied by notes on the appearance and behaviour of the living specimens and the conditions under which the catches were made. In the following account I take great pleasure in quoting these valuable and interesting observations, which were made by Dr. J. H. Barnes during his excursions among the islands of the Great Barrier Reef.

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SYSTEMATIC ACCOUNT,

with Dr. J. H. BARNES's notes on appearance and behaviour of the living specimens.

Merga violacea (Agassiz and Mayer)

Pandea violacea Mayer, 1910, pp. 119, 490, Pl. 11, Fig. 7, Pl. 12, Fig. 1, text Fig. 64.
Merga violacea Kramp, 1953, p. 265.

Green Island, 8.I.59, one specimen, 6 mm. high and wide.

"Small colourless transparent jellyfish, bullet-shaped, with square opaque internal structures and eight peripheral tentacles half an inch long" (Barnes).

Distribution: Great Barrier Reef, Australia; Fiji Islands; Pacific coast of Mexico; Nicobar Islands; coasts of India; Mediterranean Sea; Bahama Islands; Tortugas, Florida.

Leuckartiara gardineri Browne

Leuckartiara gardineri Browne, 1916, p. 181, Pl. 39, Fig. 4.
Leuckartiara gardineri Kramp, 1953, p. 267.

Green Island, 8.I.59, one specimen.

"The little red stinger. Has a very high colourless and transparent apex, like a 'nosecone'. Below this cone the bell is thicker, with bright orange internal

organs and four long pink tentacles (one inch long) which inflict a surprising sting. The sting was so sharp that I felt that this tiny creature could not be the offender, but was convinced on repeating the experiment. The pain subsided rapidly and no local effects were visible on my leg. The specimen shrank to two-thirds life size immediately after preservation" (Barnes).

The original description of this medusa was based upon one single specimen from the Amirante Islands in the Indian Ocean (Browne, 1916), and I have previously seen two small specimens from the Great Barrier Reef; these are the only records up to now.

The present specimen is well preserved, 7 mm. high in the preserved condition; the apical projection is 2·5 mm. high, bluntly conical. The four perradial tentacles are closely spirally coiled and have evidently been very long when extended. They have no ocelli, but each of the basal bulbs has an abaxial endodermal spur which is continued as a narrow canal proceeding immediately below the exumbrellar epithelium almost to the top of the apical projection of the umbrella. Owing to contraction of the bell the canals are winding in a wave-like manner. In each quadrant there are five very small tentaculae, exactly as described by Browne, the median one slightly larger than the others, which are decreasing in size towards both sides; each with a small abaxial, basal ocellus.

The folded gonads are exactly as figured by Browne, but there is no indication of a transversal bridge connecting the adradial gonads across the interradial space between them. Examination of more material may prove that this species does not belong to the genus *Leuckartiara*, which is characterised by "interradial gonads, horseshoe-shaped with folds directed perradially".

In the preserved specimen the walls of the stomach between the gonads have a bright red colour right down to the mouth lips, whose densely folded margin is white. The conical, basal part of the tentacle bulbs is red with a median, abaxial white line.

Distribution: Amirante Islands; Great Barrier Reef.

Laodicea indica Browne

Laodice indica Browne, 1905b, p. 136, Pl. 1, Fig. 5, Pl. 4, Figs. 7-11.
Laodicea indica Kramp, 1953, p. 268.

Green Island, 21.XII.58, 4 specimens, diam. 8-9 mm. – "Colourless and transparent except for a white cross in the centre, as seen on a hot cross bun" (Barnes).

Green Island, 8.I.59, 2 specimens, diam. 9-10 mm. – "Colourless with faint blue cross-shaped marking and a fringe of numerous tentacles approximately 6 mm. long" (Barnes).

Distribution: Great Barrier Reef, Australia; Torres Strait; Malayan Archipelago; Ceylon; Trivandrum coast, India; Gulf of Aden, Arabia.

Melicertissa orientalis n.sp.

Green Island, 21.XII.58, one specimen.

The genus *Melicertissa* is characterised as Laodiceidae with eight simple, narrow radial canals. Five species are described. Dr. J. Picard (Marseilles) has informed me in a letter that *Melicertissa adriatica* Neppi is identical with *Octogonade mediterranea* Zoja, which belongs to the Mitrocomidae. *M. malayica* (Maas) is distinguished by its very large number of tentacles (about 160). The remaining three species, *M. clavigera* Haeckel, *M. platygastra* Nair, and *M. mayeri* Kramp, need some discussion before the identification of the present specimen can be stated.

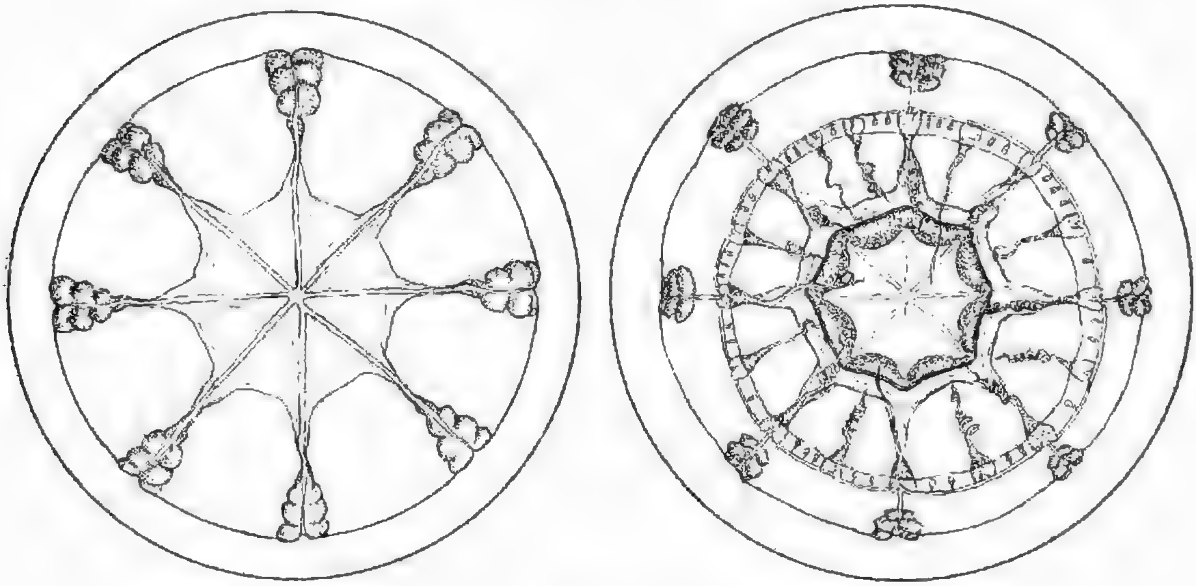
The shape of the tentacles and their basal bulbs is similar in all these species. Slight differences in the structure and position of the gonads may be

due to their stages of maturity. The width of the stomach and the vaulting of the umbrella may be dependent on the states of contraction. An adaxial ocellus is present at the base of each tentacle and cordylus in all the species.

There are, however, some distinguishing characters which seem to separate the three species mentioned above.

M. clavigera was described from the Canary Islands by Haeckel (1879, p. 135, Pl. 8, figs. 8-12). It was 10 mm. in diameter, with 8 tentacles and 24 cordyli; the stomach was narrow, and the eight mouth lips were very short. Two small but sexually mature specimens of apparently the same species are recorded from the Trivandrum coast, India, by Nair (1951, p. 59).

M. platygastra is described from a single specimen found at the Trivandrum coast, India (Nair, 1951, p. 60, Pl. 1, Figs. 16, 17). It is 7 mm. in diameter, it has



Figs. 1 and 2. *Melicertissa orientalis* n.sp.
Fig. 1, aboral view. Fig. 2, oral view.

8 tentacles (like *M. clavigera*), but a somewhat larger number of cordyli, 4-6 in each octant. The stomach is rather wide, and the species is mainly characterised by its mouth lips, which are long and lanceolate.

Mayer (1910, p. 210, Pl. 24, Figs. 2, 3) referred specimens from the Tortugas, Florida, to *M. clavigera*, though they had 16 tentacles (against 8 in *M. clavigera*), and there was only one cordylus between successive tentacles; the mouth lips were very short. Nair considered these specimens different from Haeckel's, and in accordance therewith I provided Mayer's specimens from Florida with a new name, *M. mayeri* (Kramp, 1959, p. 139).

In certain regards the present specimen from Australia differs from all these species. Examination of a greater number of specimens may reveal a variability which makes it necessary to regard them all as local forms of one species, *M. clavigera*. Provisionally it seems to me, however, more expedient to keep these species separate and describe the specimen from the Great Barrier Reef as representative of a new species.

Description of the specimen from Great Barrier Reef (Figs. 1-3).—The umbrella is flatter than a hemisphere; in its present condition, with the margin bent inward, the diameter is 11 mm. Jelly fairly thick. The stomach is broad and rather flat, 4 mm. wide; the mouth is widely open, octagonal, the mouth rim thin and smooth, with eight faintly indicated lips. The eight radial canals are continued inwards as eight narrow grooves meeting in the centre of the dorsal wall of the stomach. Outside the periphery of the stomach the radial canals are narrow, laterally compressed. The eight gonads occupy about two-fifths of the length of the radial canals, somewhat nearer to the ring canal than to the stomach; they are wavy, lateral bands with about five extensions, almost lamelliform, perpendicularly to each side. There are 17 marginal tentacles, all alike, the tentacle bulbs broadly conical with a heart-shaped base. Between successive tentacles there are 1-3, most frequently 2, cordyli, typically club-shaped, with a small distal cap of nematocysts. There is a small, black, adaxial ocellus at the base of each tentacle and cordylus.

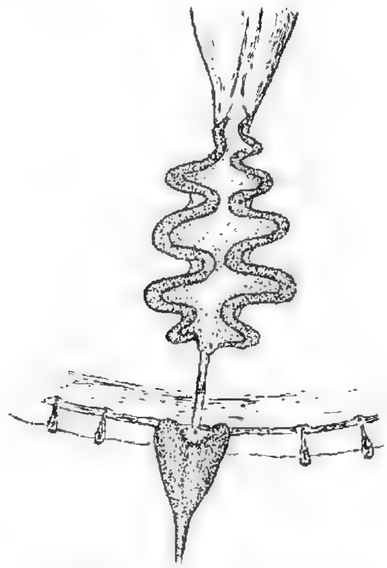


Fig. 3. *Melicertissa orientalis* n. sp. Gonad and part of bell margin, adaxial view.

The present species agrees with *M. mayeri* in the number of tentacles, but it has twice as many cordyli. *M. clavigera* and *platygastra* have only eight tentacles, and *M. platygastra* is also distinguished by its long, lanceolate mouth lips. A star-shaped figure in the centre of the stomach seems to be present in *M. clavigera*, but apparently not in *mayeri* and *platygastra*. Nematocysts in the cordyli are not mentioned in the descriptions of any of the other species; they are quite distinct in *M. occidentalis*, but are not indicated even in the enlarged figures by Haeckel (Pl. 8, Fig. 12) and Mayer (Pl. 24, Fig. 3).

As mentioned above, future studies may possibly show that these four species are identical; but since they are described from four very distant geographical regions, it would seem rather presumptuous to disregard the actual

morphological differences between them and unite them without decisive evidence.

Phialucium carolinae (Mayer)

Phialucium carolinae Mayer, 1910, p. 275, Pl. 36, Figs. 1', 1''.
Phialucium carolinae Kramp, 1953, p. 276, Figs. 2, 3.
(For further synonymy see Kramp, 1953.)

Green Island, 7.I.59, one specimen.

Palm Beach, near Cairns, 19.II.59, one specimen.

The specimen from Green Island is 18 mm. in diameter; it has 6 radial canals and 45 tentacles which, in the living specimen, were about 6 mm. long. The tentacles are all alike. Between successive tentacles usually only one very small rudimentary bulb and two marginal vesicles, but in some instances three young bulbs, the median one larger than the others, and four marginal vesicles. The gonads are narrow, along the distal one-third of the radial canals, but not quite reaching out to the umbrella margin. It was collected in shallow water at the north-eastern end of Green Island.

The specimen from Palm Beach is 14 mm. wide, with 4 radial canals and about 32 tentacles; it was found "alive but beached".

Both specimens are stated to be completely colourless when alive.

Distribution: Originally described from the southern parts of the east coast of North America. Recorded under different names from several localities in Indo-West-Pacific waters: India, the Nicobar Islands, the Nias Islands, the Philippines and Palao Islands, and southern China.

Eirene hexanemalis (Goette)

Irenopsis hexanemalis Mayer, 1910, p. 310, Fig. 171.
Eirene hexanemalis Kramp, 1953, p. 281, Fig. 5.

Green Island, 8.I.59, one specimen. "Transparent, six spokes, approximately forty tentacles a quarter inch long" (Barnes). The preserved specimen is 16 mm. in diameter.

Distribution: Widely distributed in the Indian Ocean and western Pacific, from Zanzibar in Africa to southern Japan.

Eutima curva Browne

Eutima curva Browne, 1905b, p. 138, Pl. 3, Figs. 1-3.
Eutima curva Mayer, 1910, p. 300.
Eutima curva Kramp, 1953, p. 288.

Green Island, 21.XII.58, two specimens; diameter 14 mm., with 4 tentacles and 77 marginal warts, peduncle 10 mm. long; diameter 16 mm., with 4 tentacles and 92 marginal warts, peduncle 18 mm. long. "In life they were colourless and completely transparent, but visible because of their refractile appearance, and the fact that they were swimming actively (approximately a half knot) against the tide stream. They had tentacles 4 inches (10 cm.) long before preservation, but I could detect no sting on contact" (Barnes).

Green Island, 8.I.59, two specimens: diameter 11 mm., with 4 tentacles and 68 marginal warts, peduncle crumpled; diameter 12 mm., with 4 tentacles and 124 marginal warts, peduncle 9 mm. long. "Tentacles not less than two inches (5 cm.) long. Tentacles can cause mild transient sting on the thin skin of a child" (Barnes).

In some of the specimens the cirri on the tentacle bulbs are lost.

Distribution: Ceylon; Torres Strait and Great Barrier Reef, Australia.

Aequorea australis Uchida

Aequorea australis Uchida, 1947, p. 307, Fig. 8.
Aequorea australis Kramp, 1953, p. 290, Fig. 7.

Green Island, 20.XII.58, two specimens.

Green Island, 21.XII.58, two specimens.

"Blue stripes; present in large numbers" (Barnes).

The preserved specimens are measured as follows:

Diam. 8 mm., stomach 3·5 mm., tentacles 17 + 3 young ones, radial canals 18 fully developed, 2 half developed, no gonads.

Diam. 12 mm., stomach 4 mm., tentacles 20, radial canals 16 fully developed, with tiny gonads.

Diam. 19 mm., stomach 6 mm., tentacles about 24, radial canals 15 fully developed with well-developed gonads and 7 half developed without gonads.

Diam. 21 mm., stomach ? , tentacles 29, radial canals 22 fully developed with gonads.

Distribution: Great Barrier Reef and New Guinea; ? Philippines; southern China.

Aequorea pensilis (Eschscholtz)

Aequorea pensilis Mayer, 1910, p. 333.
Aequorea pensilis Kramp, 1953, p. 295.

Cairns, at the Esplanade, 5.II.59, one specimen, diameter 34 mm., stomach 19 mm., 80 radial canals. "Colourless" (Barnes).

Aequorea macrodactyla (Brandt)

Aequorea macrodactyla Mayer, 1910, p. 333.
Aequorea macrodactyla Kramp, 1953, p. 294.

Green Island, 29.XII.58, one specimen (see below).

Green Island, 7.I.59, two specimens: Diam. 12 mm., stomach 5 mm., with 15 tentacles and about 80 radial canals; diam. 19 mm., stomach 13 mm., with 17 tentacles and about 100 radial canals. "Mauve stripes" (Barnes).

Large numbers were present on Dec. 29th, 1958, and Dr. Barnes has given an interesting account of the conditions under which they were observed. The preserved specimen is 32 mm. in diameter, the stomach 19 mm., there are 27 well-developed tentacles and 8 young tentacle bulbs, besides numerous rudimentary marginal warts; 70 radial canals, all with more or less well-developed gonads.

At first sight I was somewhat in doubt of the identification of this specimen. The dimensions and the numbers of tentacles and radial canals present no objection against referring it to *Ae. macrodactyla*, but the tentacle bulbs are not quite as we are accustomed to see them in the preserved specimens, in which they are usually very short and broad, with a prominent abaxial keel terminating above in a short and blunt spur. This is a very characteristic feature, distinguishing *Ae. macrodactyla* from all other species of *Aequorea*. In the present specimen the tentacle bulbs are as shown in Fig. 4, elongated conical, without a prominent keel, but with a pointed, triangular apical spur. This slender appearance, however, is evidently due to the fact that this specimen is in an uncommonly good state of preservation, with particularly well extended tentacles, some of them more than 4 cm. long and very thin. In life they were "approximately 3 inches (7·5 cm.) long". None of the other species of *Aequorea* possess tentacle bulbs with abaxial spurs. I do not hesitate, therefore, to refer this excellently preserved specimen to *Ae. macrodactyla*.

Distribution: Widely distributed in the warm parts of the Pacific and Indian Oceans from America to Africa; also recorded from the southern parts of the west coast of Africa, from the Patagonian coast of South America and from the West Indies.

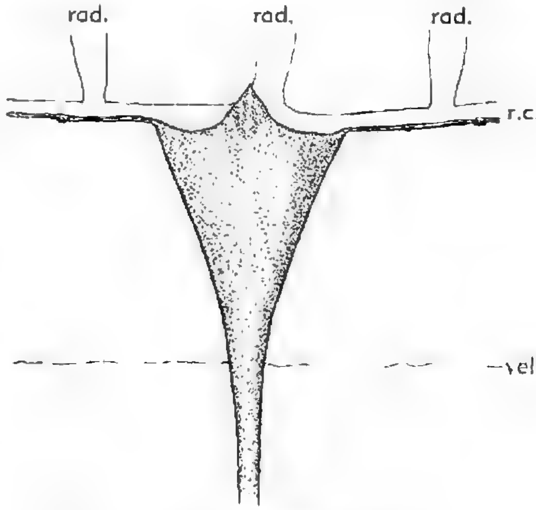


Fig. 4. *Aequorea macrodactyla*, basal bulb of a well-extended tentacle, abaxial view. *rad.*, radial canals. *r.c.*, ring canal. *vel.*, velum.

Olindias singularis Browne

Olindias singularis Browne, 1905a, p. 737, Pl. 57, Fig. 1.
Olindias singularis Mayer, 1910, p. 357.
Olindias singularis Kramp, 1953, p. 298.

Green Island, 8.I.59, one specimen, 26 mm. wide.—"Colourless jellyfish, bell translucent and colourless, crossed by two lines of white which widen out a quarter inch (ca. 6 mm.) from the centre. From this point outwards the lines have wavy brown markings superiorly and yellow flocculent masses inferiorly. Between these crossed bands, one-sixteenth of an inch (ca. 1½ mm.) from the centre, are four bright red dots. When viewed from the side these dots are seen to be columns of red specks running down beside the central tube. About 40 tentacles hang down one inch (ca. 2·5 cm.) from the periphery, which carries also seventy to eighty dark grey dots. This specimen was stranded on the sand but was still alive" (Barnes).

Distribution: Widely distributed in the tropical parts of the Indo-West-Pacific region.

Liriope tetraphylla (Chamisso and Eysenhardt)

Kramp, 1953, p. 301.

Green Island, 20.XII.58, one specimen, diameter 8·5 mm.

Distribution: All tropical and subtropical waters.

Solmundella bitentaculata (Quoy and Gaimard)

Kramp, 1953, p. 302.

Holothuria Banks, N.W. Australia, July 1958, one specimen, diameter 5·5 mm.

Distribution: Widely distributed in all the oceans, particularly common in the southern hemisphere.

Nausithoë punctata Kölliker

Green Island, 21.XII.58, 5 specimens, 8-9 mm. wide.

Green Island, 8.I.59, one specimen, 8 mm. wide.

" . . . actively swimming jellyfish, having eight short tentacles (same size in life as in preservation) and readily visible because of the eight mauve-coloured areas placed in the radial line of the tentacles. These jellyfish consistently swim with the tide" (Barnes).

Distribution: Coastal waters of all tropical and warm seas.

Pelagia noctiluca (Forskål)

Green Island, 8.I.59, one specimen, 20 mm. wide, rather crumpled.

"Pale brown jellyfish with eight tentacles, ca. 3½ cm. long, . . . bright yellow masses below the bell" (Barnes).

Distribution: Widely distributed in all warm and temperate seas.

Cephea cephea (Forskål)

Cephea cephea Mayer, 1910, p. 654, text Fig. 406.

Green Island, 6.I.59 and 7.I.59, 5 specimens, 10-21 mm. in diameter. Margin vertical beyond the deep annular furrow of the exumbrella. The gelatinous warts in the central part of the exumbrella more or less flattened.

"Jellyfish coloured brownish-purple on top, purple underneath, with finely scalloped edges and fleshy frond-like mouth arms" (Barnes).

DR. J. H. BARNES'S OBSERVATION ON THE CONDITIONS UNDER WHICH THE CATCHES WERE MADE

(with addition of the species collected)

20 Dec. 1958, Green Island. Netted at 6.30 a.m., ten feet from beach on the N.E. head of Green Island, in two feet of water. (*Aequorea australis, Liriope tetraphylla.*)

21 Dec. 1958, Green Island, 7 a.m., shortly before high tide. Clear, bright morning, light northerly wind causing very small waves. Water exceptionally clear. Bottom clean sand. Numerous jellyfish were located in a narrow (? tidal) stream running towards the north-eastern end of Green Island, and apparently coming from the north. This stream of jellyfish turned eastward on nearing the beach, and followed the line of the shore about 10 feet out. The jellyfish were concentrated near the surface, in three feet of clear water. (*Melicertissa orientalis, Laodicea indica, Eutima curva, Aequorea australis, Nausithoë punctata.*)

29 Dec. 1958, Green Island. Collected just below the surface in fifteen feet of water at twelve midday, on a full tide. Large numbers present about a hundred yards off the northern shore. Numerous salps were present among the jellyfish, and the latter were ingesting these salps in large numbers. Hot bright day with a light south-east wind. Northerly wind preceding two days. A young lad and I swam amongst these jellyfish for twenty minutes without receiving any sting. (*Aequorea macrodactyla.*)

6 Jan. 1959. Green Island. Collected at 7.30 a.m. in shallow water at north-eastern end of Green Island, about fifteen feet from shore, over clear sand. Clear, bright morning, tide just before full, wind strong northerly. (*Cephea cephea.*)

7 Jan. 1959. Green Island. Collected at 7.30 a.m., near full tide (extra high), water very clear, wind light variable northerly, in shallow water at the north-eastern end of Green Island, over clean sand. (*Phialucium carolinae, Aequorea macrodactyla, Cephea cephea.*)

8 Jan. 1959. Green Island. Collected 7.30 a.m., just after full tide in fairly rough, clean water. Wind northerly. (*Merga violacea, Leuckartiara gardineri, Laodicea indica, Eirene hexanemalis, Eutima curva, Olindias singularis, Nausithoë punctata, Pelagia noctiluca.*)

5 Feb. 1959. Cairns, at the Esplanade. Collected from prawn net at 6.30 p.m., a few feet from the beach. Dull day, very muddy water, strong south-west wind for five days, tide high. (*Aequorea pensilis.*)

19 Feb. 1959. Palm Beach, near Cairns. Time about 6.30 p.m., just after full tide, and following three days of strong northerly wind with high seas. (*Phialucium carolinae.*)

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MITCHELL'S WOMBAT IN SOUTH AUSTRALIA

BY H. H. FINLAYSON

Summary

The distribution and status of *Phascolomys mitchelli* in South Australia are discussed. Material of the species from the South-Eastern Division of South Australia is compared with that from highland districts of east Victoria and New South Wales and found to be close thereto. The use of a sub-specific name based on P. *niger* Gould *1863* to distinguish the former, as done by Iredale and Troughton, is contraindicated. The status of P. *niger* is considered and reasons given for sinking the name or limiting it to varietal usage.

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(Read 14 September 1961)

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The distribution and status of *Phascolomys mitchelli* in South Australia are discussed. Material of the species from the South-Eastern Division of South Australia is compared with that from highland districts of east Victoria and New South Wales and found to be close thereto. The use of a sub-specific name based on *P. niger* Gould 1863 to distinguish the former, as done by Iredale and Troughton, is contraindicated. The status of *P. niger* is considered and reasons given for sinking the name or limiting it to varietal usage.

In preparing a general account of the hairy-nosed wombat (*Lasiorhinus latifrons* Owen) in South Australia, various matters involving the associated bare-nosed wombat have come up for consideration. This is the species variously known in recent years as *Vombatus hirsutus* Perry, or *Vombatus ursinus platyrhinus* Owen, but which earlier was long known by the well-stabilized if technically irregular term, *Phascolomys mitchelli* Owen. Longman (1939) has given reasons for rejecting Perry's name *hirsutus* and these are accepted by Tate (1951), and until much more impressive evidence of the distinctness of *platyrhinus* is presented, there are obvious advantages in retaining the well-used and earlier *mitchelli*, and this course is followed here.

While *L. latifrons* is a prominent and characteristic South Australian animal, *P. mitchelli* in this State is a mere outlier of the main eastern population, and being a much more obscure living creature, its status and distribution are less known. The chief matters to be discussed in this note are (1) the detailed distribution in South Australia, (2) the relation of the South Australian population to that of Victoria and New South Wales, and (3) the status of *Phascolomys niger* Gould, 1863.

DISTRIBUTION

The main occurrence of Mitchell's Wombat in South Australia lies almost entirely within the South-Eastern Division of the State, but has a slight north-western extension into the lakes region at the Murray mouth. The most southerly record supported by material is at Port Macdonnell on the far south coast, and the most northerly at Murray Bridge (Wood Jones, 1924), but it is uncertain whether the latter, being based on two cave skulls, is a true riverine extension of recent time or is sub-fossil. Apart from this minor incursion, the species has not been reported from any part of the true mallee area, as we know it here, though many of the Coorong sites are fringed on the landward side with the mallee-like *Eucalyptus angulosum*. I know of no records west of the Murray River.

The South-Eastern Division has its northern boundary at lat. 35°50′ south approximately, and includes the lands to the south between the Victorian border and the sea. Its five counties have an area of about six million acres and include the highest rainfall areas of the State, with mean annual falls rang-

ing from 30 inches in the south to 20 in the north. In strong contrast to the eastern habitats of the species, which lie for the most part in highland areas with altitudes ranging up to 5000 feet or more, the present district is flat and low-lying, much of it being but little above sea level, and its highest points (except for a few volcanic cones) are but a few hundred feet and are to be found on the crests of the numerous lines of consolidated dunes which rib the country from south to north. Its south-central portion is subject to winter flooding and the vegetation varies from extensive low heaths of leptospermums, banksias and casuarinas to sclerophyll forest of considerable growth, consisting mostly of *E. obliqua* and *E. viminalis* with a floor fairly densely covered with bracken and low shrubs.

P. mitchelli occurs sporadically at least over most of this area, with the possible exception of the north-east corner beyond the railway line in the counties of Cardwell and Buckingham. Its permanent colonies, however, are largely restricted to two long, narrow, north-south zones, the first following the coast and the second more or less parallel to the Victorian border. The coastal zone is especially characteristic and presents features quite different from either the heath or stringy bark forest. Much of it is treeless or sparsely clad with the so-called dry land titree (*Melaleuca pubescens*). Limestone rangelets or low cliffs or outcrops are frequent, and the terrain is diversified by swamp and freshwater lakes of considerable extent, and is interlaced by dense jungles of melaleucas and giant cutting grass (*Gahnia* spp.). This type of habitat is best developed in the 60-mile tract between Kongorong and Robe, where it may be 10 miles deep or more, and includes portions of the Mt. Burr, Woakwine, Black and other ranges and the chain of lakes from Lake Bonney to Lake Hawden. It is here that the best chance of permanent survival of *P. mitchelli* in South Australia lies, as much of it is comparatively inaccessible and unutilized, and shelters some huge warrens with great cave-like entrances which are known to have been occupied for the century or more of European settlement.

The physiographical unit most characteristic of the ecology of *P. mitchelli* in this part of the country is created by a combination of low limestone cliffs and breakaways in which the entrances to the warrens are commonly situated, adjacent to a freshwater swamp or lake-shore, where the roots of swamp plants which form the staple of its diet are easily excavated, and the whole is commonly occluded by dense, fringing thickets. Such combinations are also found north of Robe (though in much less depth) throughout the coastwise portions of Macdonnell and along the landward side of the Coorong in Cardwell up to the south and eastern shores of Lakes Albert and Alexandrina, but the numbers of wombats fall off considerably as one goes north. The eastern tract is much narrower and does not extend as far north as the coastwise one, and is considerably less rugged and secluded. It extends, with numerous breaks, along the border country from County Caroline in the south almost to the Tatiara. The Cave Range and the Gap Range between Padthaway and Naracoorte are typical, but the colonies here are smaller and more exposed to human interference than on the coast.

These two main belts of permanent occupation act as reservoirs from which, from time to time, excess wombats are pushed out from overcrowded warrens to exploit new habitats of suitable character in the intervening areas. The process is highly selective as to sites and level heaths, in particular, are seldom, if ever, colonized. In 1920, for example, wombats from near the inflow of the Murray into Lake Alexandrina invaded a sandy undulating area of broom and callitris scrub in the Hundred of Seymour between Tailem Bend and Cooks Plains. This is the most northerly occurrence in South Australia of which I

have personal knowledge, and in much the most arid surroundings, but it was short-lived. Similar excursions from the Coorong give fluctuating wombat populations to the long chain of depressions known locally as the Floodwater, which lies parallel with the Coorong in County Cardwell, and which is occasionally flooded with freshwater by an overflow from the lower south-east district. Some of these colonies are as much as 17 miles from the coast.

The habits of wombats in these newly established communities are often somewhat different from those in the parent colonies. In the latter, especially when in proximity to settlements, they are generally excessively shy, quite strictly nocturnal and cryptic in all their movements, and until motor transport with its night-lighting of roads and paddocks by headlamps became common, it was not unusual to find settlers who had spent a lifetime in close proximity to occupied warrens without once sighting the occupants. It is usually very difficult to get specimens from these old warrens in deep limestone. The inmates are wary of traps and pitfalls and will endure long periods of fasting in the burrows, or break out through a new exit, rather than risk ground that has been interfered with, and short of bulldozing the whole structure into rubble and driving the animals into nets, little will avail.

In about 1930, a relatively new colony was located in the Hundred of Joanna near the Victorian border. I visited it in 1933 and found it situated in stringy bark forest on a rise of deep sandy soil carrying a heavy growth of bracken. Burrows were numerous over an area of two or three acres, and the occurrence was atypical in that there were no limestone or other rocky outcrops anywhere in the vicinity, and wombats were much more in evidence than is usually the case, and had been doing heavy damage to fencing. With the aid of a settler and a fox terrier, we were able to obtain four very easily in a morning's work. The procedure was to send the dog into the warren to locate the wombat. On his doing so, the latter attempts to crush the dog against the roof of the tunnel by butting upwards with his powerful hindquarters, and careless or overeager dogs are sometimes killed in this way. When the two make contact, a muffled uproar ensues, which is easily located at the surface, so that one may dig directly down upon the disputants, release the dog and secure the wombat. They struggle violently when taken and are extremely powerful, but make no attempt to bite if the head is avoided. They were despatched easily with chloroform. In May, one large female was found to be carrying a naked pouch young.

Most of the burrows here were quite shallow and short, sometimes no more than two feet deep and ten feet long, but in one case where the wombat could not be overtaken, the burrow had extended 40 feet from the entrance and descended to six feet when the attempt was abandoned. Two years earlier, this same settler, using the same technique (but without the anaesthetic) had killed 29 wombats in this colony within a few weeks.

This is much the easiest method of obtaining undamaged specimens, but is only practicable under the unusual circumstances of the above occurrence. In the high country between Tumbarumba and Batlow in the Tumut district of New South Wales, I have seen *P. mitchelli* taken very easily by flooding the warrens by short circuiting the heads of creeks with a shallow race to the mouth of a burrow at a lower level.

Increase in land utilization in the South-Eastern Division of South Australia, which has been greatly accelerated in recent years, will inevitably reduce the total wombat population to some extent. But short of a widespread epidemic of disease or systematic persecution with extermination as its deliberate object,

there seems no reason why *P. mitchelli* should not maintain a strong hold in this State indefinitely.

THE RELATION OF THE SOUTH AUSTRALIAN POPULATION TO THAT OF VICTORIA AND NEW SOUTH WALES

Although no detailed work has been done which would justify a fixed opinion on the matter, it is easy at the present time to gain the impression by random interrogation that *P. mitchelli* is much less well represented in the Victorian districts west of Melbourne, than elsewhere in its overall range. In south-eastern South Australia on the one hand, and in north-eastern Victoria, Gippsland, and south-eastern New South Wales, on the other, the presence of wombats is universally known to bush naturalists, if only through the evidence of worked warrens. But in much of western Victoria, there seems to be little or no such knowledge of it. This is substantially true, for example, of such "likely" areas as the Otway Peninsula and the Grampian Hills, which abound in what would be considered typical wombat country in this State.

The only recent occurrences known to me (excepting the immediate vicinity of the border) are in the (Victorian) Black Range west of the Grampians and at Bridgewater Bay in the Portland District, east of the Glenelg River. The latter is an apparently vigorous colony and stragglers from it have been seen in the Surrey River scrubs, twelve miles north, and in earlier years it evidently had a coastal and sub-coastal extension to the east, as specimens in the National Museum, Melbourne, come from Port Fairy (1912), Warrnambool (1857), and Mortlake (1911); other western specimens in the same collection are from Colac (1866) just north of the Otway Ranges, and Lyonville (1908) on the Dividing Range.

If a discontinuity does actually exist between the population of New South Wales and eastern Victoria, on the one hand, and the South-Eastern Division of South Australia on the other, it would tend to support the action of Iredale and Troughton (1934, p. 34) in applying a sub-specific name to the latter, though, as I shall show, the name used and the characters on which it is based, have been erroneously chosen. Meanwhile, as no direct comparisons have hitherto been made, I have assembled the relevant material which is available locally, and done so, with results which are summarized below under the three heads of dimensions, pelage and cranial characters.

The South Australian material from the South-Eastern Division includes 11 skins and 21 skulls, which are fully localized and a further five skins and nine skulls which are from Zoological Garden exhibits in Adelaide and which are probably of the same precaptive origin as the rest. The Victorian and New South Wales collections comprise seven skins and eight skulls all fully localized and are from the Wombat Range area south-east of Benalla in north-east Victoria and from the Murray Range area of the Tumut district of New South Wales. The data quoted and conclusions drawn, are based entirely on the localized material.

External Dimensions

Reliable dimensions, personally made upon animals in the flesh, are available for four examples only—three of them from the Joanna colony of South Australia mentioned above, and one from the Tumut district of New South Wales. These are quoted in full below for record purposes (Table 1), but are of little use in a comparison of populations, owing to marked differences of age, the New South Wales specimen being very aged and emaciated, and the others

scarcely adult. Dimensions of total length and pes length have been collected from the skins examined, but they are so often falsified by distortion, that to quote them here is to confuse the issue. All that can be said here under this head is that the average size of the eastern highland animal may be a little larger than in South Australia, and the feet perhaps proportionally stouter and with heavier digits and claws. However, the skull series from South Australia contains examples much larger than any belonging to the South Australian skins examined, and considerably larger than the largest eastern skulls available, so that even in this there is uncertainty.

TABLE 1.

	South Australia			N.S.W.
	♂ Young adult	♀ Sub-adult	♀ Young adult	♂ Very aged
Total length: dorsal contour	865 mm	825 mm	895 mm	960 mm
Tail: from anus	62	52	47	—
Tail: from dorsal flexure	28	27	20	—
Chest girth	630	580	650	640
Mid girth	—	—	—	730
Manus length	70	68	77	83
Nail of 3rd digit	22	21	27	33
Pes length (s. u.)	83	78	82	98
Nail of 3rd digit	23	23	27	29
Ear, length	68	70	70	70
Ear, max. breadth	40	38	36	43
Rhinarium to eye	72	67	72	85
Eye to ear	90	90	97	100
Eye, intercanthal width	18	17	18	—
Weight in lbs.	43	35	48	51

External dimensions of *Phascolomys mitchelli* Owen.

Pelage

In general colour, the South Australian skins, with one exception, are a comparatively uniform batch of grizzled drab dorsal colour. The basal colour on the dorsum is a variable brown or drab, rather markedly contrasted with the terminal (external) effect, which is a blend of brown or drab ticked with the dull white or ivory of the sub-terminal band and with the black or bistre of the tips and guards. There is a fairly constant darkening on the crown and nape and sometimes on the rump, and the back may be irregularly mottled where the basal colour is locally more in evidence than the grizzling. The facial areas are pale drab and less ticked than the back, and there is a patch of greyish white at the base of the ears. The sides are grizzled like the back, but paler and the entire ventrum is externally pale drab or greyish white without grizzling, except for a variably developed belt across the mid-belly. The ear backs and dorsum of manus and pes are darkened to a variable brown or drab without grizzling. Length of coat, density and coarseness all vary within wide limits.

The single exception represents the "yellow" phase of Thomas (1888) and of Gould (1863, op. cit. pl. 58). The dorsal coat is very short, rather soft and a uniform pale buffy drab, very obscurely ticked with slightly darker buff. There is practically no darkening or other differentiation of crown, ear backs, manus or pes, and the sides and ventrum are much like the back.

The "black" phase is absent from the South Australian material examined, though Wood Jones (1924, p. 264) records it as occurring here. The ear in all the South Australian specimens is small and normal for *Phascolomys*.

The eastern batch of seven skins from east Victoria and New South Wales are much more variable, but fall into two camps—four "blacks" and three grizzled greys. The latter are very similar indeed to the South Australian skins of the same category, but have a denser and somewhat longer coat, and ventrally are darker and more grizzled over the mid-belly, though this is not constant.

The four "blacks" are erythristic rather than melanistic variants, and are very uniformly coloured on all surfaces. The entire dorsum is a rich ferruginous umber with a variable overlay of black or bistre, but scarcely any ticking. The distinction of the basal dorsal colour from the terminal external colour which is a marked and constant feature of the grey pelage from both areas, is very much reduced and the sides, ventrum, limbs, manus, pes and ear backs are all coloured much like the back. The coat is sometimes conspicuously coarse and bristly on the forebacks and arms. I cannot confirm the opinion of A. S. le Souef (1926), that the two main colour phases occur in uniform mutually exclusive populations. Both in the Victorian and New South Wales portions of the collection, "blacks" and greys were taken in close proximity. There appears to be no cranial distinction whatever between them.

When examples in corresponding phases of pelage are compared, the general agreement between the eastern specimens here examined and those of south-eastern South Australia is quite close in spite of the marked physical differences in their habitats. With adequate series there is little doubt that a considerable proportion of the grey skins from the two areas would be virtually identical.

Cranial Characters

The range and approximate mean for 14 cranial dimensions of four adult skulls from east Victoria and New South Wales, on the one hand, and 13 adult skulls from the South-Eastern Division of South Australia are shown in Table 2. As more than half the crania are not sexed, the sexual factor has been ignored in the group comparison. The age criterion generally adopted was the closure of either one or both of the basicranial sutures. There is much irregularity in this closure as between the two sites. Usually the posterior (basioccipital-basisphenoid) precedes the anterior (basisphenoid-presphenoid), but there are numerous exceptions. However, the time of closure at either site is sufficiently delayed to exclude obvious sub-adults, and is a better guide than the coronal suture, which is occluded much earlier. The values quoted for the basicranial and basifacial axes and the facial index are approximate only as the landmark when the suture was closed had to be estimated from the general appearance of the bone and this was sometimes unrevealing.

The range for the South Australian group is invariably wider than for the eastern four, and provides in every case a ± overlap of the latter. The difference in the means exceeds 2 p.c. in only two values. The length of diastema is lower (−5 p.c.) in South Australian skulls, and the anterior palatal foramina also lower (−17 p.c.). The latter figure is calculated upon the maximum length observed; but the pair are often very unequally developed and when a mean value of both is employed, the difference drops to (−10 p.c.). From this very unequal sample, therefore, it might be inferred that the South Australian skull is metrically very close to that of the Victorian and New South Wales highlands, with perhaps a tendency to a slightly shorter muzzle region.

and a rather decidedly shorter anterior palatal foramen. It shows no reduction in overall size, but on the contrary its largest examples somewhat exceed the largest available from the eastern group.

In non-metrical characters, the skulls from the two groups show very marked individual variation, though the range of this is necessarily somewhat greater in the larger South Australian series, and the average age in the eastern group is somewhat higher. Even so, it is possible to select numerous pairs from the two areas which are virtually identical both in size and structure and this correspondence would probably be increased if more eastern material were available.

TABLE 2.

	Eastern Victoria and Southern N.S.W. 4 Adults (♂♀)	South Eastern South Australia 13 Adults (♂♀)	N.S.W. 1 Adult	S. Aust. 1 Adult
Greatest length	176·9-186·0 (182·6)	166·6-198·9 (180·1)	186·0	187·7
Basal length	158·9-165·0 (161·0)	148·8-176·9 (161·3)	165·0	161·8
Greatest breadth	129·0-136·0 (133·6)	121·7-146·5 (134·3)	134·1	135·5
Nasals length	71·0- 76·9 (73·6)	68·1- 82·3 (72·0)	76·9	72·9
Nasals greatest breadth	50·5- 56·5 (53·4)	48·9- 57·7 (53·9)	53·9	55·9
Least interorbital breadth	53·5- 63·5 (57·8)	52·0- 65·8 (58·0)	58·5	58·7
Least intertemporal breadth	43·3- 47·2 (45·8)	41·1- 52·5 (45·8)	46·7	48·7
Palate length	103·0-111·5 (107·9)	96·5-119·2 (108·1)	111·5	111·2
Diastema length	38·1- 44·5 (41·3)	33·0- 47·9 (39·3)	44·5	39·5
Ant. palatal foramina	12·9- 13·7 (13·4)	9·7- 14·0 (11·1)	13·5	11·0
Basicranial axis	51·5- 52·5 (51·9)	46·0- 58·0 (50·8)	51·5	50·5
Basifacial axis	107·5-116·5 (112·3)	103·8-120·5 (110·8)	116·5	111·1
Facial index	204·7-226·2 (216·6)	194·8-236·5 (217·1)	226·2	219·8
P^4-M^4	51·0- 53·6 (52·1)	45·7- 55·5 (51·4)	51·2	53·7

Skull dimensions of *Phascolomys mitchelli* Owen.

The slight differences which have been brought to light by this examination of external and cranial characters are much less impressive than the general agreement and suggest that the two groups studied are essentially one population and that the discontinuity in the range in western Victoria (if real) is of very recent origin.

Whether such differences as can be made out call for trinomial distinction may be left for future work on more comprehensive series to decide, but from what has been done it is obvious that a name based on *P. niger* Gould, a form supposedly of small size, with an ear like *Lasiorhinus* and black coat colour, is quite unsuitable.

THE STATUS OF *P. NIGER* GOULD 1863

In 1863, Gould (op. cit. text to Pl. 60) made a brief reference under this name to a Zoological Gardens exhibit in London of a melanistic bare-nosed wombat, which was stated to have a long, pointed ear as in *Lasiorhinus latifrons*. No material of the original specimen is certainly preserved, it was not figured, and its place of origin was unknown. Attempts have been made to supply all three of these deficiencies with the result that the name and what it connotes have fallen into inextricable confusion. Thus:

(1) Thomas (1888, p. 215) selected a specimen "h" of the British Museum collection as the "probable type of *P. niger* Gould". This, however, is an enormous wombat with a skull of basal length 185 mm., which is far larger than the largest examples in the collection which I have just examined, which

includes some unusually large crania. This circumstance conflicts sharply with the later ideas which evolved as to the nature of *P. niger* which have tended to regard it as a small or even dwarfish form.

(2) Tate (1951, p. 7) considered that Gould had figured *P. niger* in his Mammals of Australia, though he admitted that the name was not directly associated with any illustration. The two plates 55 and 56 of blackish wombats in Gould's work are both labelled *P. vombatus* and represent blackish phases of the Tasmanian wombat (*P. tasmaniensis* of later authors) which has normally short ears which are sufficiently well shown. They do not, in my opinion, represent Gould's *P. niger*.

(3) Gould (1863, text to plate 60) attempted to make good the deficiency of locality by equating *P. niger* to a blackish form described by the natives to Angas (1861) as inhabiting the Murray scrubs of South Australia and contrasted by them with a "big yellow fellow". Here again Gould fell into confusion which has been confounded by some later commentators. His attempts to link *P. niger* with the dark wombat of the river front is defeated by the obvious identity of this animal with *Lasiorhinus latifrons*. A frequent, perhaps even normal colour of well-nourished young adult *Lasiorhinus* in fresh pelage is a dark, blackish grey – the mottled reddish grey skins which are common in collections are nearly always from emaciated, aged and feeble wombats which abound in most warrens and are easily collected by reason of their habit of basking in a semi-comatose condition on top of the burrow. To the natives, who are connoisseurs of meat, the "black"-coated examples would hold pride of place in their accounts to a stranger, while the supernumary "greys" might well be overlooked. No wombat is a permanent denizen of the deep mallee areas of South Australia, but *Lasiorhinus* alone does penetrate it from the River Murray flats to a depth of a mile or two, in the reaches between the Chucka Bend and Morgan. On the other hand, the "big yellow fellow" fits some phases of *P. mitchelli* quite well and both species would be known to natives who hunted the lower reaches of the river and the area about the lakes and the Murray mouth, and who presumably were Angas's informants. Krefft's record of *P. niger* from Pt. Lincoln (*infra*) and that of R. Tate (1879) from the Bunda Plateau of the Eucla district, are probably both based on the same misconception as the above.

In the century which has elapsed since Gould wrote, no evidence of recent wombats other than *Lasiorhinus latifrons* has been adduced in the regions between the Murray and the Western Australian border, except at the southern extremity of Eyre Peninsula where the rainfall rises to nearly 20 inches and reaches the limiting value of the *P. mitchelli* habitats of the South-Eastern Division of the State. The existence here of a small wombat of *Phascolomys* type is confirmed by the presence of material in the South Australian Museum. Krefft (1871, 1872) reported the presence of *P. niger* Gould in the same area, and although the record was probably due to confusion with *L. latifrons*, it has prompted Iredale and Troughton (1934) to postulate the existence of a subspecies of *P. mitchelli* corresponding in characters to Gould's original statements on *P. niger* as to its melanism and long pointed ear (and to which has been later added small size as well), and ranging from western Victoria over the whole of lower South Australia to Eyre Peninsula. This conception, however, is quite erroneous and cannot stand, firstly, because bare-nosed wombats are quite absent from the greater part of the supposed range, and secondly, because the largest population of *P. mitchelli* within this range is almost impeccably normal in its large size, and short ear, and has a low incidence of melanism.

Clearly, if the name *niger* is to be used at all, it must be restricted to a small area at the apex of Eyre Peninsula. I am of opinion, however, that as a taxonomic concept, Gould's *P. niger*, without material, authentic locality or adequate description, and constantly susceptible of three interpretations, is altogether too nebulous to serve any practical purpose of classification, and its retention (like that of *Macropus elegans* Lambert in the Macropodidae), will be a stumbling block to the clarification of wombat terminology in this part of Australia. It should either be discarded or reduced to varietal or tetranomial use, as Tate has done (1951).

ACKNOWLEDGMENT

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MITCHELL'S WOMBAT IN SOUTH AUSTRALIA

BY B. G. FORBES

Summary

Bedded magnesite of the Montacute Dolomite Formation is inferred to have formed in areas of shallow water marginal to the sea, chiefly because magnesite occurs frequently as a conglomerate and is closely associated with mud-cracked beds. Most dolomite beds are concluded to be of marine origin, and thus the formation as a whole formed under paralic conditions. Magnesium carbonate may have been precipitated by alkaline waters of continental origin reacting with sea water. The appropriate balance of conditions for the formation of magnesite was achieved most often in the Copley region where tectonism was at a minimum. Tectonism was greatest in the Port Germein region. Much less magnesite was formed in this region possibly through dilution by active streams. Conditions in the Rhynie-Bundaleer region, where little or no magnesite was formed, are thought to have been largely marine.

MAGNESITE OF THE ADELAIDE SYSTEM: A DISCUSSION OF ITS ORIGIN

by B. G. Forbes*

(Read 14 September 1961)

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Bedded magnesite of the Montacute Dolomite Formation is inferred to have formed in areas of shallow water marginal to the sea, chiefly because magnesite occurs frequently as a conglomerate and is closely associated with mud-cracked beds. Most dolomite beds are concluded to be of marine origin, and thus the formation as a whole formed under paralic conditions. Magnesium carbonate may have been precipitated by alkaline waters of continental origin reacting with sea water.

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INTRODUCTION

In a previous paper (1960) I described the petrography and stratigraphy of the Montacute Dolomite. This Proterozoic formation contains in many places extensive sedimentary beds of conglomerate composed of magnesite, a mineral more commonly associated with bodies of altered serpentine.

Opinions on the origin of the South Australian magnesite have been given previously. Sir Douglas Mawson, who was chiefly responsible for recognizing the magnesite stratigraphically, stated in 1947: "The magnesium-rich sediments were obviously laid down in shallow, saline land basins". Spry (1952) discusses the evidence and suggests an original chemical deposition of hydromagnesite in a large, shallow basin. Sprigg (1952) uses the term "brecciola", apparently inferring the transport of fragmental magnesite by turbidity currents.

It is proposed here to offer suggestions, based on the field and laboratory work briefly reported in the previous paper, on the mode of origin of the sedimentary magnesite, beginning on what appears to be the firmer ground, the mechanical aspects of the problem, and passing on to chemical aspects, for which there is little field evidence.

DEPOSITIONAL ENVIRONMENT

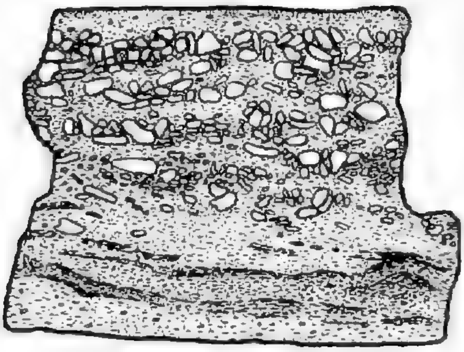
Mechanical Factors

Two very evident and critical features of the magnesitic beds are their conglomerate structure, resembling mud-pellet conglomerates, and their associated polygonal cracking. From these it is not unreasonable to infer that the original sediment was subject to periods of subaerial exposure and erosion in a continental environment, possibly an area marginal to the sea.

* Department of Mines, Adelaide. Published with the permission of the Director of Mines.

A few magnesite beds possess a structure like mud-balls, suggesting the rolling up of plastic material. An original plasticity is also suggested by the irregularly-squeezed appearance of some magnesite conglomerate fragments. The rounding of magnesite fragments may be due in larger part to shaping of a plastic substance rather than to wear. This would seem to apply particularly to pebbles with thickened margins. Fabrics of some magnesitic rocks are illustrated in Figs. 1 to 4.

In contrast, most dolomite beds show no evidence of erosion or subaerial exposure. It is concluded that most dolomite is of marine, although perhaps shallow-water, origin. The depositional environment of the formation as a whole may thus be termed paralic.



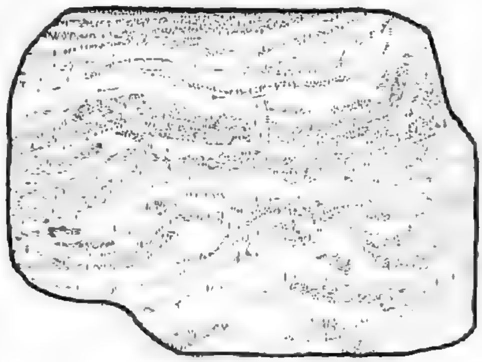


Fig. 1 Section normal to bedding in a magnesite-dolomite rock from Copley; specimen 12 cm. in length. White magnesite pebbles up to 1 cm. in length occur in a grey matrix of sand- and silt-size dolomite and magnesite. The lower part of the specimen is richer in dolomite and shows wavy bedding.

Fig. 2. Section normal to bedding in a magnesite rock from Copley; specimen 9 cm. in length. The fabric of the rock has been revealed by weathering, possibly hydration, of very fine-grained magnesite. The apparent curling-up and fracturing of the thin layers may have been due to mud cracks.

Alternate transgression and regression may be used to explain the reverse graded bedding structure often found in magnesite conglomerate and arenite beds. Below is a suggested outline of a cycle of transgression and regression and associated sedimentation.

It is presumed that while magnesium carbonate, with a little dolomite, is formed in marginal lagoons, dolomite or calcium carbonate is formed in the neighbouring shallow sea. When sea level rises, the calcareous zone migrates inland. In still-stand periods the magnesitic mud, originally deposited as normal sedimentary laminae, occasionally suffers dessication. This facilitates subsequent erosion. During the succeeding lowering of sea level the earlier-deposited magnesium carbonate is reworked and deposited in deeper water. If regression proceeds far enough, some calcium carbonate or dolomite will be eroded. The finest detritus is deposited farthest from shore, but as the shore-line migrates toward deeper water this detritus will be covered by coarser material.

The spreading effect of an oscillating sea level may also serve in explaining the widespread and uniform nature of what appear to be shallow-water sediments. Another explanation of the great extent and uniformity of individual

magnesite beds along their strike is that this strike may very well be parallel to the original shore-line.

In areas where it is prominent, arkosic sediment may be expected to accumulate during regression and become reworked during transgression.

Chemical Factors

From the previous considerations it would seem that the original form of magnesium carbonate was chemically deposited in shallow basins marginal to the sea. The proximity of sea water solves the problem of a source of the magnesium in magnesite. There remains the question of how magnesium was removed from solution eventually to form a carbonate.

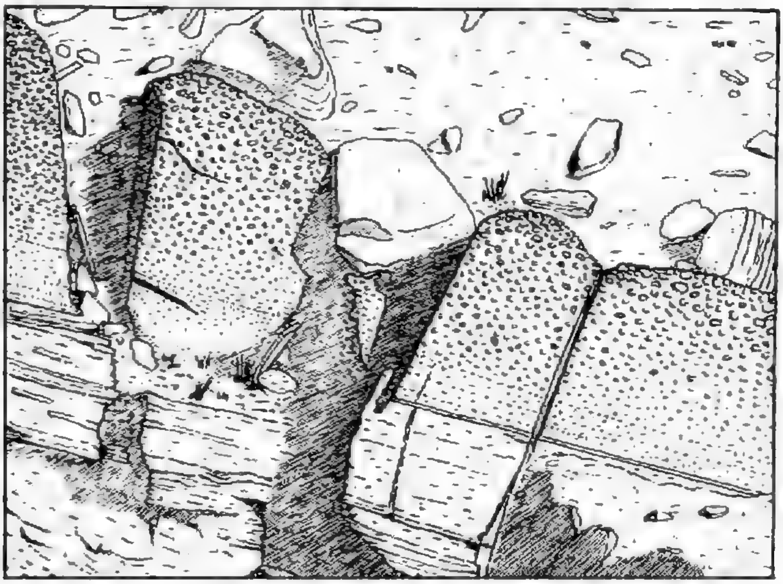


Fig. 3. A magnesite conglomerate bed, about 2 feet thick, overlying thin-bedded dolomite near Arkaroola. Magnesite pebbles are much coarser at the top of the bed than at its base.

Fine-grained carbonates, normally calcite and aragonite, are formed in present-day sea and lake waters. Their deposition is generally attributable to loss of dissolved carbon dioxide attendant upon increases in water temperature, although an increase in pH due to organic activity could also be effective.

Natural precipitation of magnesium carbonate from present-day saline waters appears to be a rare event. Two interesting examples of natural occurrences are as follows: Alderman and von der Borch (1960) report hydromagnesite within the sedimentary dolomite deposits of the South Australian Coorong lagoons; Vital (1951) discovered a colloidal substance containing basic magnesium carbonate which was floating on the surface and also occurred on the bottom of Lake Elton, U.S.S.R. Von der Borch (personal communication) also reports primary magnesite precipitation in one Coorong lagoon.

A basic magnesium carbonate may be precipitated from sea water under normal surface conditions by the addition of alkali or alkali carbonate; Hepburn (1940) concludes that this basic magnesium carbonate is of variable composition due to the adsorption of HCO_3^- ions by colloidal magnesium hydroxide.

Irving (1926) found that 50 p.c. of the dissolved magnesium in sea water was precipitated by the addition of enough sodium carbonate to produce a pH of about 10·5; calcium carbonate precipitates at a pH of 8·5 and magnesium carbonate begins to precipitate at pH 9.

It is thus possible that the magnesite of the Montacute Dolomite was originally precipitated as such, or precipitated in a hydrated or basic form and converted to magnesite during diagenesis. The precipitating agent is unknown: possibly alkalis were provided inorganically in marginal playas or a high pH may have been produced organically. The only evidence of organic activity is the carbon within dolomite rock.

PALAEOGEOGRAPHY

The original sedimentary environment is hypothetically depicted in general terms in Fig. 5, which omits the magnesite occurrence near Olary and is based on a few sparsely scattered points of observation. It is thus probable that the true pattern of sedimentation was rather more complicated than that suggested.

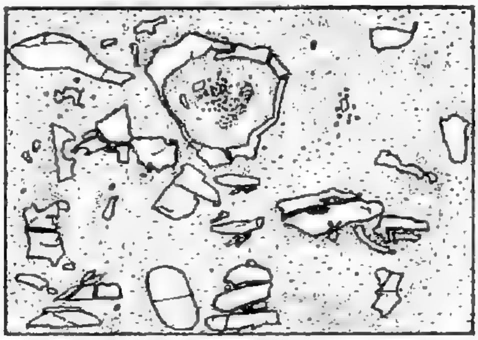


Fig. 4. Section normal to bedding in a magnesite-dolomite rock from Copley. What may represent a mud-ball (above centre) is about 5 cm. across in the section. It is composed from centre outward, of magnesite arenite, fine-grained dark-grey dolomite and curved flakes of white fine-grained magnesite. Elsewhere in the rock angular fragments of magnesite up to 5 cm. in length are scattered in a matrix of dark-grey, fine-grained dolomite. Irregular darker areas are richer in dolomite.

The figure shows in the north an area of weak marginal uplift and to the west an area of strong uplift. Other minor areas of strong uplift appear near Johnburgh and Adelaide. The depositional basin is divided into areas of paralic sedimentation without magnesite, paralic sedimentation with magnesite and marine sedimentation.

The area most favourable for the formation of magnesite appears to have been centred near Copley, where the greatest proportion occurs, where the beds are thickest and where the magnesite conglomerate pebbles are largest. Near Copley, also, sand sedimentation was at a minimum. This favourable area was terminated to the north near Witchelina, where fine sands formed the greater part of the deposits. The sands are presumed to have come from a north-western source area of moderate relief. Current bedding structures at Witchelina and Arkaroola respectively indicate flow from north-westerly and northerly directions. The slumping at Witchelina and Arkaroola is in agreement with the depicted outer margin of the depositional area; slumping at Copley may be due to a minor variation in relief within the main basin.

South of Copley subsidence was stronger and the known depositional area narrower. Slumping and current bedding structures at Depot Creek suggest a source for detritus to the west and a downward slope of the depositional surface to the east. The proportion of magnesite, size of pebbles and thickness

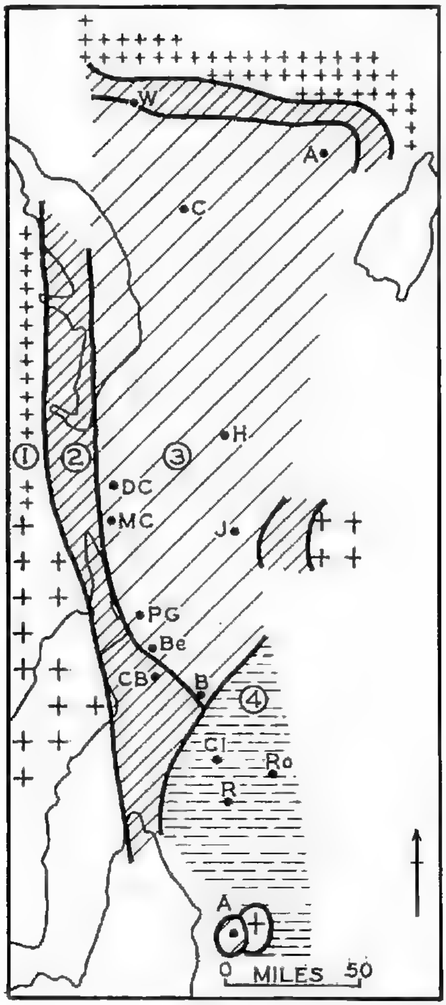


Fig. 5. Hypothetical plan showing areas of uplift and sedimentation during deposition of the Montacute Dolomite Formation. Postulated areas of marginal uplift (1) are indicated by crosses; large crosses indicate stronger positive movement. Area (2) was devoted to paralic sedimentation unaccompanied by magnesite, and area (3) to paralic conditions with magnesite deposition. In area (4) marine conditions prevailed. Names of the abbreviated localities are, from north to south: Witchelina, Arkaroola, Copley, Hawker, Depot Creek, Mundallio Creek, Johnburgh, Port Germein Gorge, Beetaloo, Crystal Brook, Bundaleer, Clare, Robertstown, Rhynie, Adelaide.

of beds was less, while proportion and grain-size of sand was greater. In the north there appears to have been a suitable balance between the supply of (?alkaline) continental water and normal marine conditions over a broad and fairly flat depositional area. By contrast, in the south a stronger marginal uplift

possibly upset this balance by too great a supply from streams. Proximity to an open sea may also have had an adverse effect on the formation of magnesite.

The thinness of the Montacute Dolomite and the absence of magnesite and detrital sediment from it between Adelaide and Bundaleer suggest that conditions were predominantly marine in this region. Near Adelaide there appears to have been a small isolated area where prevailed conditions somewhat similar to those at Copley.

CONCLUSIONS

The gist of this discussion is that the sedimentary magnesite of the Montacute Dolomite Formation most likely formed in unusually alkaline marginal lagoons, but it is not known how the depositional area became so alkaline.

Whether or not this last question will ever be answered, much more certainly remains to be learnt about this unusual rock and the formation which it characterizes.

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IRVING, L., 1926. The Precipitation of Calcium and Magnesium from Sea Water. J. Mar. biol. Ass. U.K., **14**, pp. 441-446.

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MEMOIR AND BIBLIOGRAPHY, DUNCAN CAMPBELL SWAN

Summary

DUNCAN CAMPBELL SWAN, M.Sc.
1907-1960

Duncan Campbell Swan died in London in December, 1960, at the end of a period of study leave during which he had paid attention to his special interests in the field of economic entomology, in particular to grape phylloxera, to mites of horticultural interest and to the biological control of St. John's wort leaf beetle (*Chrysomela hyperici*).

Mr. Swan was elected a member of the Society in 1932 soon after his arrival in South Australia to take up a position of assistant entomologist at the Waite Agricultural Research Institute under the late Professor James Davidson. His service to the Society included periods as Secretary (1940-1942), Vice-President and President (1947-1949), and a further period of five years as Councillor.

Mr. Swan was born and educated in Perth, Western Australia, and graduated with an Honours degree in Science in the University of that State. He was awarded a Hackett Research Studentship. He was awarded the degree of Master of Science by the University of Adelaide in 1935.

During the period 1942-1946 he served in the Pacific Area with the Medical Unit of the Royal Australian Air Force as entomologist, and in 1946 succeeded Professor Davidson as head of the Department of Entomology at the Waite Institute, with status from 1955, of Reader in the University of Adelaide.

This Department has had a threefold duty to the State of South Australia. The first has been to provide an advisory service in economic entomology to the State Department of Agriculture, the second to provide courses in entomology in the faculties of the University and the third to pursue research into the problems suggested by the deficiencies in knowledge revealed in the exercise of the other two functions.

Mr. Swan was an extremely competent biologist, and it is perhaps in the exercise of his wide knowledge of Australian fauna and flora that he excelled in his contribution to the first of these duties. Over the years he contributed a succession of papers to the Journal of Agriculture of South Australia, excellently illustrated by himself, on the insects of major economic importance to the State. His service with the Air Force gave him, in addition, a wide knowledge of medical entomology.

He chose to make his contribution to the third of these duties by becoming the Australian authority on the grape phylloxera, not only by his knowledge of the classical literature on this pest but by undertaking field studies in the infested areas in eastern Australia. Another field of knowledge to which he paid attention was the taxonomy and biology of the mites of horticultural importance.

His premature death has meant that much of this special knowledge has remained unpublished. However, his field data and his collections have been brought together and referred to the appropriate specialists with a view to ultimate publication in appropriate form.

J.A.P.
H.M.B.

1934. Dermatitis caused by a mite (*Pediculoides ventricosus*) and its occurrence in Australia. *Med. J. Aust.*, 1934, Nov. 3, 573.
A scarab beetle (*Aphodius tasmaniae* Hope) destructive to pastures in the south-east of South Australia. *J. Agr. S. Aust.*, 37, 1149-1156.

LIST OF LECTURES GIVEN AT MEETINGS DURING THE YEAR 1960-61

Nov., 1960. Dr. T. O. Browning: "Preliminary Observations on the Ecology of the Australian Kangaroo Tick *Ornithodoros gurneyi*".

Apr., 1961. Mr. J. R. Harris: "Salt in Turf Grasses".

May, 1961. Mr. F. F. Thonemann: "Principles of Digital Computers".

June, 1961. Mr. S. B. Hart: "The Likely Development of Metropolitan Adelaide, 1961-1991".

Exhibits

During the year, the following members exhibited material at Ordinary Meetings:

Dr. C. G. Stephens and Mr. K. H. Northcote—exhibits of new soil maps.

Mr. L. W. Parkin and Mr. B. P. Webb—tectonic maps.

Dr. B. Daily—artificial diamond dust.

CHANGE OF RULES AND BY-LAWS

The following Rules and By-laws were amended at the Annual General Meeting in October, 1960, to read as follows:

Rule XI.

(1) The financial year of the Society shall end on the last day of June in each year, and the Annual Meeting shall be held in the month of July or in such other month and upon a date and at a place to be appointed by the Council.

By-law II.

(4) Nominations for officers and members of the Council, on the prescribed form, shall be lodged with the Secretary by 4 p.m. on the day of the June Council Meeting.

By-law VI.

(1) The library shall be supervised by the Librarian. Subject to control by the Council, he shall be responsible for the receipt of publications, the distribution of the Society's transactions and the general care and maintenance of the library and the loan of books, (a) directly to members of the Society, (b) through the Commonwealth Inter-Library loan system, to members and other scientific and technical organizations, and to the general public.

SIR WILLIAM MITCHELL, CENTENARIAN

Summary

The hay-itch mite, *Pediculoides ventricosus* (Newport) (Acarina : Pediculoididae) in South Australia. *J. Agr. S. Aust.*, 37, 1289-1299.
The red-legged earth mite, *Halotydeus destructor* (Tucker) in South Australia, with remarks upon *Penthaleus major* (Duges). *J. Agr. S. Aust.*, 38, 353-367.
1935. A weevil attacking mallow (*Malva parviflora* L. and *M. nicaeensis* All.) in South Australia. *J. Agr. S. Aust.*, 38, 1125-1128.
1936. Berlese's fluid. Remarks upon its preparation and use as a mounting medium. *Bull. ent. Res.*, 27 (3), 389-391.
1937. Insects and other invertebrates of economic importance in South Australia during the period July, 1934, to June, 1936. *J. Agr. S. Aust.*, 40, 717-731.
1940. The lucerne flea (*Smynthurus viridis* L.). *J. Agr. S. Aust.*, 43, 462-471.
1941. The control of ants. *J. Agr. S. Aust.*, 44, 373-375.
The control of silverfish. *J. Agr. S. Aust.*, 44, 420-422.
Notes on the lesser grain borer (*Rhizopertha dominica* Fabr.) in South Australia. *J. Agr. S. Aust.*, 45, 45-52.
1942. The bark beetle, *Hylastes ater* Payk. (Coleoptera : Scolytidae), attacking pines in South Australia. *J. Agr. S. Aust.*, 46, 86-90.
(With Stephen, V. A.) An injector for liquid fumigants. *J. Aust. Inst. Agric. Sci.*, 8 (1), 26.
1949. Fruit flies. Dept. Agric. S. Aust., 1949.
(With Browning, T. O.) The black field cricket (*Gryllulus servillei* Sauss.). *J. Agr. S. Aust.*, 52, 323.
1951. (With Lower, H. F.) An interim note on the control of the lucerne flea and red-legged earth mite. *J. Agr. S. Aust.*, 54, 433.
1955. Locusts and grasshoppers in South Australia. Dep. Agric. S. Aust. Bull. No. 440 (1956).

Joint Papers with J. Davidson

1933. Davidson, J., and Swan, D. C. A method for obtaining samples of the population of Collembola (Symphyleona) in pastures. *Bull. ent. Res.*, 24 (3), 351-352.
1938. Andrewartha, H. G., Davidson, J., and Swan, D. C. The "grasshopper" problem in South Australia. *J. Agr. S. Aust.*, 41, 565-571.
Andrewartha, H. G., Davidson, J., and Swan, D. C. Vegetation types associated with the plague grasshopper in South Australia. Dep. Agric. S. Aust. Bull. No. 333.
1943. Davidson, J., and Swan, D. C. The incubation period of the eggs of *Halotydeus destructor* Tucker (Acarina) at different temperatures. *Aust. J. exp. Biol. med. Sci.*, 22, 107-110.

SIR WILLIAM MITCHELL

K.C.M.G., M.A., D.Sc. — *Centenarian*

The President, Council and Fellows of the Society extend their congratulations to Sir William Mitchell on his attaining his hundredth birthday during the year. Sir William became a Fellow of the Society in 1925, when he was Vice-Chancellor of the University, on the same occasion as did the late Sir George Murray, then Chancellor of the University, during the presidency of the late Sir Douglas Mawson. This was at a time when scientific activity in the University was rapidly developing. The Society was to become closely associated with the University for the next few years, and Mawson was succeeded in the office of President by a series of professors of the University who, all of them, contributed both to the Councils of the Society and to its publications. The election of the Vice-Chancellor and Chancellor to fellowship at this time was a most appropriate and welcome token of their interest in and support of the aims of the Society.

BALANCE SHEET

Summary

ROYAL SOCIETY OF SOUTH AUSTRALIA (INCORPORATED)
REVENUE ACCOUNT

Receipts and Payments for Nine Months Ended 30th June, 1961

		£	s.	d.
To Balance, 1/10/60		590	11	1
,, Subscriptions		340	15	4
,, Government Grant		1,312	0	0
,, Sale of Publications, etc.		76	19	7
,, Rent of Rooms		20	9	6
,, Interest—				
Endowment Fund	£363 1 1			
Savings Bank	32 5 4			
		395	6	5
		£2,736	1	11

	£	s.
By Printing and Publishing Volume 84, Reprints, etc.	1,408	19
,, Library Assistants	67	16
,, Clerical Assistance	125	0
,, Printing and Stationery	80	5
,, Postage and Duty Stamps	48	1
,, Cleaning and Polishing	53	18
,, Insurance	3	1
,, Lighting	7	17
,, Binding	297	4
,, Publications, etc.	6	0
,, Cabinet	31	10
,, Scales	6	15
,, Balance— Savings Bank of S.A., Rundle St.	599	13 1
	£2,736	1 1
,, Account Outstanding at 30/6/61	282	3
,, Balance of Uncommitted Funds	317	10 1

Audited and found correct.

F. M. ANGEL
N. S. ANGEL, A.U.A. Com. } Hon. Auditors.

F. J. MITCHELL,
Hon. Treasurer.

Adelaide, 6th July, 1961.

ENDOWMENT FUND

		£	s.	d.
To Balance, 1/10/60		9,670	0	0
,, Investment Interest—				
Com'wealth Inscribed Stock	£344 11 1			
S.A. Inscribed Stock	4 10 0			
S.A. Gas Co. Bonds	14 0 0			
		363	1	1
		£10,033	1	1

		£	s.
By Revenue Transfer		363	1
,, Balance—			
Com'wealth Inscribed Stock	£9,220 0 0		
S.A. Inscribed Stock	150 0 0		
S.A. Gas Co. Bonds	300 0 0		
		9,670	0
		£10,033	1

Audited and found correct. The Commonwealth Stock has been verified by certificate, and the S.A Stock and the Gas Co. Bonds have been inspected in the hands of the Treasurer.

F. M. ANGEL
N. S. ANGEL, A.U.A. Com. } Hon. Auditors.

F. J. MITCHELL,
Hon. Treasurer.

Adelaide, 6th July, 1961.

AWARDS OF THE SIR JOSEPH VERCO MEDAL AND LIST OF FELLOWS, 1961

Summary

AWARDS OF THE SIR JOSEPH VERCO MEDAL

1929 Prof. Walter Howchin, F.G.S.
1930 John McC. Black, A.L.S.
1931 Prof. Sir Douglas Mawson, O.B.E., D.Sc., B.E., F.R.S.
1933 Prof. J. Burton Cleland, M.D.
1935 Prof. T. Harvey Johnston, M.A., D.Sc.
1938 Prof. J. A. Prescott, D.Sc., F.A.C.I.
1943 Herbert Womersley, A.L.S., F.R.E.S.
1944 Prof. J. G. Wood, D.Sc., Ph.D.
1945 Cecil T. Madigan, M.A., B.E., D.Sc., F.G.S.
1946 Herbert M. Hale, O.B.E.
1955 L. Keith Ward, I.S.O., B.A., B.E., D.Sc.
1956 N. B. Tindale, B.Sc.
1957 C. S. Piper, D.Sc.
1959 C. G. Stephens, D.Sc.
1960 H. H. Finlayson.
1961 R. L. Specht, Ph.D.

LIST OF FELLOWS

AS AT 30th SEPTEMBER, 1961.

Those marked with an asterisk (*) have contributed papers published in the Society's Transactions. Those marked with a dagger (†) are Life Members.

Any change in address or any other changes should be notified to the Secretary.

Note.—The publications of the Society are not sent to those members whose subscriptions are in arrears.

Honorary Fellows

Date of Election	Date of Honorary Election	
1895	1949	*Cleland, Prof. J. B., M.D., Dashwood Road, Beaumont, S.A.—*Verco Medal*, 1933; *Council*, 1921-26, 1932-37; *President*, 1927-28, 1940-41; *Vice-President*, 1926-27, 1941-42.
1913	1955	*Osborn, Prof. T. G. B., D.Sc., 103 Ward Street, North Adelaide—*Council*, 1915-20, 1922-24; *Vice-President*, 1924-25, 1926-27; *President*, 1925-26.
1912	1955	*Ward, L. K., I.S.O., B.A., B.E., D.Sc., 22 Northumberland Street, Heathpool, Marryatville, S.A.—*Council*, 1924-27, 1933-35; *Vice-President*, 1927-28; *President*, 1928-30.

Fellows

Date of Election

1946. *Abbie, Prof. A. A., M.D., D.Sc., Ph.D., Department of Anatomy, University of Adelaide, North Terrace, Adelaide, S.A.
1959. Aitken, P., B.Sc., South Australian Museum, North Terrace., Adelaide, S.A.
1927. *Alderman, Prof. A. R., Ph.D., D.Sc., F.G.S., Department of Geology, University of Adelaide, North Terrace, Adelaide, S.A.—*Council*, 1937-42, 1954-57.
1951. *Anderson, Mrs. S. H., B.Sc., 31 Lakeman Street, North Adelaide, S.A.
1935. *Andrewartha, H. G., M.Ag.Sc., D.Sc., Zoology Dept., University of Adelaide, North Terrace, Adelaide, S.A.—*Council*, 1949-50; *Vice-President*, 1950-51, 1952-53; *President*, 1951-52.
1935. *Andrewartha, Mrs. H. C., B.Agr.Sc., M.Sc. (nee H. V. Steele), 29 Claremont Avenue, Netherby, S.A.
1929. *Angel, F. M., 34 Fullarton Road, Parkside, S.A.
1939. *Angel, Miss L. M., M.Sc., 2 Moore Street, Toorak, Adelaide, S.A.
1960. Archbold, R. T., South Australian Museum, North Terrace, Adelaide, S.A.
1945. *Bartlett, H. K., L.Th., 2 Abbotshall Road, Lower Mitcham, S.A.
1958. Bauer, F. H., Department of Geography, University of California, Riverside, California, U.S.A.
1950. Beck, R. G., B.Ag.Sc., R.D.A., Lynewood Park, Mil-Lel, via Mount Gambier, S.A.
1932. Begg, P. R., D.D.Sc., L.D.S., Shell House, 170 North Terrace, Adelaide.
1928. Best, R. J., D.Sc., F.A.C.I., Waite Institute (Private Mail Bag, No. 1), Adelaide.

Date of Election

1956. Black, A. B., A.S.A.S.M., M.I.M.M., 36 Woodcroft Avenue, St. Georges, S.A.
1934. Black, E. C., M.B., B.S., Magill Road, Tranmere, S.A.
1950. Bonnin, N. J., M.B., B.S., F.R.C.S. (Eng.), F.R.A.C.S., 19 Marlborough St., College Park, S.A.
1945. †*Bonython, C. W., B.Sc., A.A.C.I., Romalo House, Romalo Avenue, Magill, S.A.
1945. *Boomsma, C. D., M.Sc., B.Sc.For., 6 Celtic Avenue, South Road Park, S.A.
1947. *Bowes, D. R., Ph.D. (Lond.), D.I.C., F.G.S., Department of Geology, University, Glasgow, Scotland.
1957. *Brookes, Miss H. M., Dept. of Entomology, Waite Institute (Private Mail Bag, No. 1), Adelaide, S.A.
1957. Buick, W. G., B.A., c/o Public Library, North Terrace, Adelaide, S.A.
1944. *Burbidge, Miss N. T., M.Sc., C.S.I.R.O., Div. Plant Industry, P.O. Box 109, Canberra, A.C.T.
1958. Buring, L., 51 Richmond Road, Westbourne Park, S.A.
1922. *Campbell, Prof. T. D., D.D.Sc., D.Sc., 24 Lymington Street, Tusmore, S.A.—*Council*, 1928-32, 1935, 1942-45; *Vice-President*, 1932-34; *President*, 1934-35.
1960. Candler, C., 2 Harris St., Glenelg, S.A.
1959. Carmodus, B. B., R.D.Ocu., 26 Dequettville Terrace, Kent Town, S.A.
1953. Carter, A. N., B.Sc., 8 Scott St., Maroubra Bay, N.S.W.
1960. Catley, D. E., 8 Cudmore Terrace, Whyalla, S.A.
1957. *Chippendale, G. M., B.Sc., Lindsay Avenue, Alice Springs, N.T.
1955. Clothier, E. A., Hydroelectric Commission, Hobart, Tas.
1949. Colliver, F. S., Geology Department, University of Queensland, St. Lucia, Brisbane, Q.
1929. *Cotton, B. C., F.R.Z.S., J.P., South Australian Museum, North Terrace, Adelaide—*Council*, 1943-46, 1948-49; *Vice-President*, 1949-50, 1951-52; *President*, 1950-51; *Programme Secretary*, 1959-.
1956. Crawford, A. R., B.Sc., Mines Department, 169 Rundle St., Adelaide, S.A.
1956. Daily, B., Ph.D., Department of Geology, University of Adelaide, North Terrace, Adelaide, S.A.—*Programme Secretary*, 1957-59.
1951. Davidson, A. L. C., Ph.D., B.Sc., c/o Messrs. Simpson & Brookman, 35 Grenfell St., Adelaide, S.A.
1950. Deland, C. M., M.B., B.S., D.P.H., D.T.M., 29 Gilbert Street, Goodwood, S.A.—*Council*, 1952-60.
1930. Dix, E. V., Box 12, Aldgate, S.A.
1937. Doull, K. M., M.Ag.Sc., Waite Institute (Private Mail Bag, No. 1), Adelaide, S.A.
1959. Dunlop, P. R. G., B.Sc., 13 Walton Ave., Clearview, S.A.
1944. Dunstone, S. M. L., M.B., B.S., 170 Payneham Road, St. Peters, S.A.
1931. Dwyer, J. M., M.B., B.S., 157 East Terrace, Adelaide, S.A.
1933. *Eardley, Miss C. M., M.Sc., F.L.S., Department of Botany, University of Adelaide, North Terrace, Adelaide, S.A.—*Council*, 1943-46.
1945. *Edmonds, S. J., B.A., M.Sc., Ph.D., Zoology Department, University of Adelaide, North Terrace, Adelaide, S.A.—*Council*, 1954-55; *Programme Secretary*, 1955-56; *Secretary*, 1956-57.
1902. *Edquist, A. G., 19 Farrell Street, Glenelg, S.A.—Council, 1949-53.
1956. *Eichler, H., Dr.rer.nat., State Herbarium, Botanic Garden, North Terrace, Adelaide, S.A.
1959. Fielder, D. R., B.Sc., Dept. of Zoology, University of Adelaide, North Terrace, Adelaide, S.A.
1927. *Finlayson, H. H., 305 Ward St., North Adelaide—*Verco Medal*, 1960; *Council*, 1937-40.
1951. Fisher, R. H., 21 Seaview Road, Lynton, S.A.
1960. Fonder, H. W., 15 Auburn Ave., Myrtle Bank, S.A.
1958. *Forbes, B. G., Ph.D., F.G.S., 9 Flinders Road, Hillcrest, S.A.
1958. Ford, A. W., F.I.C.S., A.C.C.S., 380 South Terrace, Bankstown, N.S.W.
1959. Forde, N., Dip.For., C.S.I.R.O., Canberra, A.C.T.
1954. Gibson, A. A., A.W.A.S.M., Mines Department, 169 Rundle St., Adelaide, S.A.
1953. *Glaessner, M. F., D.Sc., Geology Department, University of Adelaide, North Terrace, Adelaide, S.A.—*Council*, 1953-54; *Vice-President*, 1958-59.
1935. †Goldsack, H., Coromandel Valley, S.A.
1959. Green, Miss L. M. A., B.A., M.Sc., Dept. of Anatomy and Histology, University of Adelaide, North Terrace, Adelaide, S.A.
1948. Gross, G. F., M.Sc., South Australian Museum, Adelaide, S.A.—*Secretary*, 1950-53.
1944. Guppy, D. J., B.Sc., c/o W.A. Petroleum Co., 251 Adelaide Terrace, Perth, W.A.

Date of Election

1922. *HALE, H. M., O.B.E., 12 Belle Vue Place, Unley Park, S.A.—*Verco Medal*, 1946; *Council*, 1931-34, 1950-53, 1956-; *Vice-President*, 1934-36, 1937-38; *President*, 1936-37; *Treasurer*, 1938-50, 1953-56.
1949. HALL, D. R., Tea Tree Gully, S.A.
1930. †HANCOCK, N. L., 3 Bewdley, 66 Beresford Road, Rose Bay, N.S.W.
1946. *HARDY, MRS. J. E. (nee A. C. Beckwith), M.Sc., Stewart Ave., Salisbury, S.A.
1944. HARRIS, J. R., B.Sc., c/o Waite Institute (Private Mail Bag, No. 1), Adelaide, S.A.
1960. HARRISON, J., 7 McQuillan Ave., Renown Park, S.A.
1958. HAYBALL, J. F., B.Sc., 68 Pleasant Avenue, Glandore, S.A.
1960. HAYMAN, D. L., Ph.D., Genetics Department, University of Adelaide, North Terrace, Adelaide, S.A.
1944. HERRIOT, R. I., B.Agr.Sc., 49 Halsbury Avenue, Kingswood, S.A.
1951. HOCKING, L. J., 46 Kauri Parade, Seacliff, S.A.
1959. HORWITZ, R. G. H., D.Sc., Glenside Road, Woodbury Hill, Stirling West, S.A.
1924. *HOSSFELD, P. S., Ph.D., 132 Fisher Street, Fullarton, S.A.
1944. HUMBLE, D. S. W., M.P.S., J.P., 238 Payneham Road, Payneham, S.A.
1947. *HUTTON, J. T., B.Sc., A.S.A.S.M., 10 Bellevue Place, Unley Park—*Council*, 1957-.
1928. IFOULD, P., 14 Wyatt Road, Burnside, S.A.
1960. INGHAM, L. J., 34 Lexington Road, Henley South, S.A.
1945. *JESSUP, R. W., M.Sc., 6 North Penno Parade, Belair, S.A.
1950. *JOHNS, R. K., B.Sc., Department of Mines, 169 Rundle St., Adelaide, S.A.
1957. JOHNSON, B., B.Sc.Agr., Ph.D., Waite Institute (Private Mail Bag, No. 1), Adelaide.
1958. *JOHNSON, W., B.Sc. (Hons.), 33 Ryan Avenue, Woodville West, S.A.
1954. KEATS, A. I., B.E., 44 LeFevre Terrace, North Adelaide, S.A.
1939. †KHAKHAR, H. M., Ph.D., M.B., F.R.G.S., Khakhar Buildings, C.P. Tank Road, Bombay, India.
1949. *KING, D., M.Sc., c/o Utah Development Co., Room 37A, T. & G. Bldg., Brisbane, Q.
1933. *KLEEMAN, A. W., Ph.D., Dept. of Geology, University of Adelaide, North Terrace, Adelaide, S.A. *Secretary*, 1945-48; *Vice-President*, 1948-49, 1950-51; *President*, 1949-50.
1960. KUCHEL, R. H., Roseworthy Agricultural College, Roseworthy, S.A.
1941. *LANGFORD-SMITH, T., B.A., M.Sc., Ph.D., Dept. of Geography, University of Sydney, Sydney, N.S.W.
1922. LENDON, G. A., M.D., B.S., F.R.C.P., c/o Elder's Trustee and Executor Co. Ltd., 37 Currie Street, Adelaide, S.A.
1958. LINDSAY, H. A., 110 Cross Road, Highgate, S.A.
1948. LOTHIAN, T. R. N., N.D.H. (N.Z.), Director, Botanic Garden, Adelaide, S.A.—*Treasurer*, 1952-53; *Council*, 1953-57; *Vice-President*, 1957-58, 1960-61; *President*, 1958-60.
1931. *LUDBROOK, MRS. N. H., M.A., Ph.D., D.I.C., F.G.S., Department of Mines, 169 Rundle St., Adelaide, S.A.—*Council*, 1958-60; *Vice-President*, 1960-61; *President*, 1961.
1953. MAELZER, D. A., B.Sc. (Hons.), Waite Institute (Private Mail Bag, No. 1), Adelaide.
1939. MARSHALL, T. J., M.Agr.Sc., Ph.D., C.S.I.R.O., Division of Soils (Private Mail Bag, No. 1), Adelaide, S.A.—*Council*, 1948-52.
1959. MARTIN, MISS H. A., c/o Department of Botany and Biology, University of British Colombia, Vancouver 8, Canada.
1950. MAYO, G. M. E., B.Ag.Sc., Ph.D., 29 Angas Rd., Lower Mitcham, S.A.
1920. MAYO, SIR HERBERT, LL.B., Q.C., 90 Northgate St., Unley Park, S.A.
1948. McCULLOCH, R. N., M.B.E., B.Sc., B.Agr.Sc., Roseworthy Agricultural College, Roseworthy, S.A.
1945. †*MILES, K. R., D.Sc., F.G.S., 11 Church Road, Mitcham, S.A.
1952. MILNE, K. L., F.C.A., 14 Burlington Street, Walkerville, S.A.
1939. MINCHAM, V. H., 30 Wainhouse Street, Torrensville, S.A.
1958. *MIRAMS, R. C., B.Sc., 5 Myrtle Rd., Seacliff, S.A.
1951. *MITCHELL, F. J., South Australian Museum, North Terrace, Adelaide, S.A.—*Treasurer*, 1959-.
1933. MITCHELL, PROF. SIR M. L., M.Sc., c/o Elder's Trustee and Executor Co. Ltd., 37 Currie Street, Adelaide.
1925. †MITCHELL, PROF. SIR W., K.C.M.G., M.A., D.Sc., Fitzroy Terrace, Prospect, S.A.
1936. *MOUNTFORD, C. P., 25 First Avenue, St. Peters, Adelaide, S.A.
1957. *MUMME, IVAN A., B.Sc. (Hons.), c/o Australian Atomic Energy Commission, P.O., Coogee, N.S.W.
1944. NINNES, A. R., B.A., R.D.A., 62 Sheffield Street, Malvern, S.A.

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1945. *Northcote, K. H., B.Agr.Sc., A.I.A.S., C.S.I.R.O., Division of Soils (Private Mail Bag, No. 1), Adelaide, S.A.
1930. Ockenden, G. P., B.A., 68 Holbrooks Rd., Flinders Park, S.A.
1956. O'Driscoll, E. S., B.Sc., 9 Vinall Street, Dover Gardens, S.A.
1937. *Parkin, L. W., M.Sc., A.S.T.C., Department of Mines, 169 Rundle St., Adelaide, S.A.—*Secretary*, 1953-56; *Vice-President*, 1956-57, 1958-59; *President*, 1957-58.
1949. Parkinson, K. J., B.Sc., 91 Stuart St., Hillcrest, S.A.
1929. Paull, A. G., M.A., B.Sc., 10 Milton Avenue, Fullarton Estate, S.A.
1926. *Piper, C. S., D.Sc., C.S.I.R.O., Division of Soils (Private Mail Bag, No. 1), Adelaide—*Verco Medal*, 1957; *Council* 1941-43; *Vice-President*, 1943-45, 1946-47; *President*, 1945-1946.
1948. Powrie, J. K., B.Sc., Waite Institute (Private Mail Bag, No. 1), Adelaide, S.A.
1925. *Prescott, Prof. J. A., C.B.E., D.Sc., F.R.A.C.I., F.R.S., 82 Cross Road, Myrtle Bank, S.A.—*Verco Medal*, 1938; *Council*, 1927-30, 1935-39, *Vice-President*, 1930-32; *President*, 1932-33; *Editor*, 1955-.
1957. *Pringle, Miss L. A. B., Box 876c, G.P.O., Adelaide, S.A.
1945. *Pryor, L. D., M.Sc., Dip.For., 32 La Perouse Street, Griffith, Canberra, A.C.T.
1950. *Rattigan, J. H., M.Sc., Newcastle University College, Tigh's Hill, 2N, N.S.W.
1944. Riceman, D. S., D.Sc., B.Agr.Sc., C.S.I.R.O., Division of Biochemistry, Adelaide.
1947. Riedel, W. R., B.Sc., c/o Scripps Institution of Oceanography, Dept. of Palaeontology, University of California, La Jolla, California, U.S.A.
1947. Rix, C. E., 42 Waymouth Avenue, Glandore, S.A.
1953. Rogers, Prof. W. P., D.Sc., Ph.D., F.A.A., M.I.Biol., Zoology Dept., University of Adelaide, North Terrace, Adelaide, S.A.
1951. Rowe, S. A., 22 Shelley Street, Firle, S.A.
1950. Rudd, Prof. E. A., B.Sc., A.M., University of Adelaide, North Terrace, Adelaide, S.A.
1951. Russell, L. D., c/o Adelaide Boys' High School, West Terrace, Adelaide, S.A.
1945. Rymill, J. R., Old Penola Estate, Penola, S.A.
1933. Schneider, M., M.B., B.S., 175 North Terrace, Adelaide, S.A.
1959. Schodde, R., Division of Land Research and Divisional Survey, C.S.I.R.O., Canberra, A.C.T.
1951. *Scott, T. D., M.Sc., South Australian Museum, North Terrace, Adelaide, S.A.—*Programme Secretary*, 1953-54, 1956-57; *Secretary*, 1957-.
1957. Sharman, G. B., D.Sc., Department of Zoology, University, North Terrace, Adelaide, S.A.
1925. *Sheard, H., Port Elliot, S.A.
1936. *Sheard, K., D.Sc., C.S.I.R.O., Division of Fisheries and Oceanography, University of W.A., Nedlands, W.A.
1954. Shepherd, R. G., B.Sc., c/o Department of Mines, 169 Rundle St., Adelaide, S.A.
1959. Shepley, Miss E. A., M.Sc., 97 North Terrace, Kensington Gdns., S.A.
1934. Shinkfield, R. C., 57 Canterbury Avenue, Trinity Gardens, S.A.
1925. †Smith, Sir Tom Barr, Kt., B.A., 25 Currie Street, Adelaide, S.A.
1941. *Southcott, R. V., M.D., B.S., D.T.M. & H., 13 Jasper Street, Hyde Park, S.A.—*Council*, 1949-51, 1952-53, 1957-60; *Treasurer*, 1951-52; *Vice-President*, 1953-54, 1955-56, 1961; *President*, 1954-55, 1960-61.
1936. Southwood, A. R., M.D., M.S. (Adel.), M.R.C.P., 170 North Terrace, Adelaide, S.A.
1947. *Specht, R. L., Ph.D., Botany Department, University of Melbourne—*Verco Medal*, 1961; *Council*, 1951-52, 1958-60; *Programme Secretary*, 1952-53; *Vice-President*, 1961.
1936. †*Sprigg, R. C., M.Sc., 5 Baker Street, Somerton Park, S.A.
1949. *Spry, A. H., M.Sc., Geology Department, University of Tasmania, Hobart, Tas.
1951. Steadman, Rev. W. R., 8 Blairgowrie Road, St. Georges, S.A.
1938. *Stephens, C. G., D.Sc., C.S.I.R.O., Division of Soils (Private Mail Bag, No. 1), Adelaide—*Verco Medal*, 1959; *Council*, 1952-54; *Vice-President*, 1954-55, 1956-57; *President*, 1955-56.
1955. Swaine, C. D., M.B., B.S., 220 Esplanade, Largs North, S.A.
1951. Swirski, P., M.Ag.Sc., 13 Derwent Ave., Rostrevor, S.A.
1960. Symons, E. F., Uranium Treatment Plant, Port Pirie, S.A.
1934. Symons, I. G., 35 Murray Street, Lower Mitcham, S.A.—*Editor*, 1947-55; *Council*, 1955-58.
1958. Taylor, D. J., Dept. of Entomology, Waite Institute (Private Mail Bag, No. 1), Adelaide, S.A.
1959. Taylor, D. J., 23 Westbourne St., Prahran East, Vic.

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1929. *TAYLOR, J. K., B.A., M.Sc., C.S.I.R.O., Division of Soils (Private Mail Bag, No. 1), Adelaide—*Council*, 1940-43, 1947-50; *Librarian*, 1951-52; *Vice-President*, 1952-53, 1954-55; *President*, 1953-54.

1948. *THOMAS, I. M., M.Sc. (Wales), M.I.Biol., Department of Zoology, University of Adelaide—*Secretary*, 1948-50; *Council*, 1950-53; *Vice-President*, 1955-56, 1957-58; *President*, 1956-57; *Assistant Editor*, 1958-.

1938. *THOMAS, MRS. I. M. (nee P. M. Mawson), M.Sc., Department of Zoology, University of Adelaide, North Terrace, Adelaide, S.A.

1957. THOMAS, J., B.Sc., Woodleigh Road, Blackwood, S.A.

1959. THOMSON, B. P., M.Sc., 33 Oaklands Road, Parkholme, S.A.

1940. *THOMSON, CAPT. J. M., 135 Military Road, Semaphore South, S.A.

1923. *TINDALE, N. B., B.Sc., South Australian Museum, North Terrace, Adelaide, S.A.—*Verco Medal*, 1956; *Secretary*, 1935-36; *Council*, 1946-47; *Vice-President*, 1947-48, 1949-50; *President*, 1948-49; *Librarian*, 1952-.

1955. *TUCKER, B. M., B.Sc., C.S.I.R.O., Division of Soils (Private Mail Bag, No. 1), Adelaide, S.A.

1959. TWIDALE, C. R., Ph.D., M.Sc., Dept. of Geography, University of Adelaide, North Terrace, Adelaide, S.A.

1959. *TYLER, M. J., Dept. of Physiology, University of Adelaide, North Terrace, Adelaide, S.A.

1960. TYNAN, A. E., c/o Australian Mineral Development Laboratories, Flemington St., Parkside, S.A.

1950. VEITCH, J. T., Box 92, Port Lincoln, S.A.

1953. WATERMAN, R. A., B.A., M.A., Ph.D., Wayne State University, Detroit, Michigan, U.S.A.

1954. *WEBB, B. P., M.Sc., Department of Mines, 169 Rundle St., Adelaide, S.A.

1954. WELLS, C. B., B.Ag.Sc., Broadlees, Waverley Ridge, Crafers, S.A.

1959. WHELAN, PROF. R. F., Department of Physiology, University of Adelaide, North Terrace, Adelaide, S.A.

1946. *WHITTLE, A. W. G., M.Sc., Department of Economic Geology, University of Adelaide, North Terrace, Adelaide, S.A.

1950. WILLIAMS, L. D., "Dumosa," Meningie, S.A.

1946. *WILSON, PROF. A. F., D.Sc., Dept. of Geology, University of Queensland, St. Lucia, Brisbane, Qld.

1938. *WILSON, J. O., 42 Wilson Terrace, DaCosta Park, Glenelg, S.A.

1933. *WOMERSLEY, H., F.R.E.S., A.L.S. (Hon. causa), South Australian Museum, North Terrace, Adelaide—*Verco Medal*, 1943; *Secretary*, 1936-37; *Editor*, 1937-43, 1945-47; *President*, 1943-44; *Vice-President*, 1944-45; *Rep. Flora and Fauna Protection Committee*, 1945; *Treasurer*, 1950-51, 1956-59.

1954. *WOMERSLEY, H. B. S., D.Sc., Botany Department, University of Adelaide, North Ter-Adelaide, S.A.—*Council*, 1960-.

1944. WOMERSLEY, J. S., B.Sc., Dept. of Forests, Lae, New Guinea.

1957. WOODS, R. V., B.Sc., Mt. Crawford, S.A.

1960. *WOPFNER, H., Ph.D., 16 Reece Ave., Klemzig, S.A.

1949. YEATES, J. N., A.M.I.E., A.M.I.M.E., Highways and Local Government Dept., Adelaide, S.A.

1944. ZIMMER, W. J., Dip.For., F.L.S. (Lond.), 7 Rupert St., Footscray West, W.12, Vic.

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